Gesundheit Nordhessen Holding AG

Zentrum Klinikum Kassel

Invasive Beatmung von COVID-19-Patienten

Ralf M Muellenbach

Campus Kassel
University of Southamptom

COVID-19-Fälle – Stand 03.04.2020 Hessen

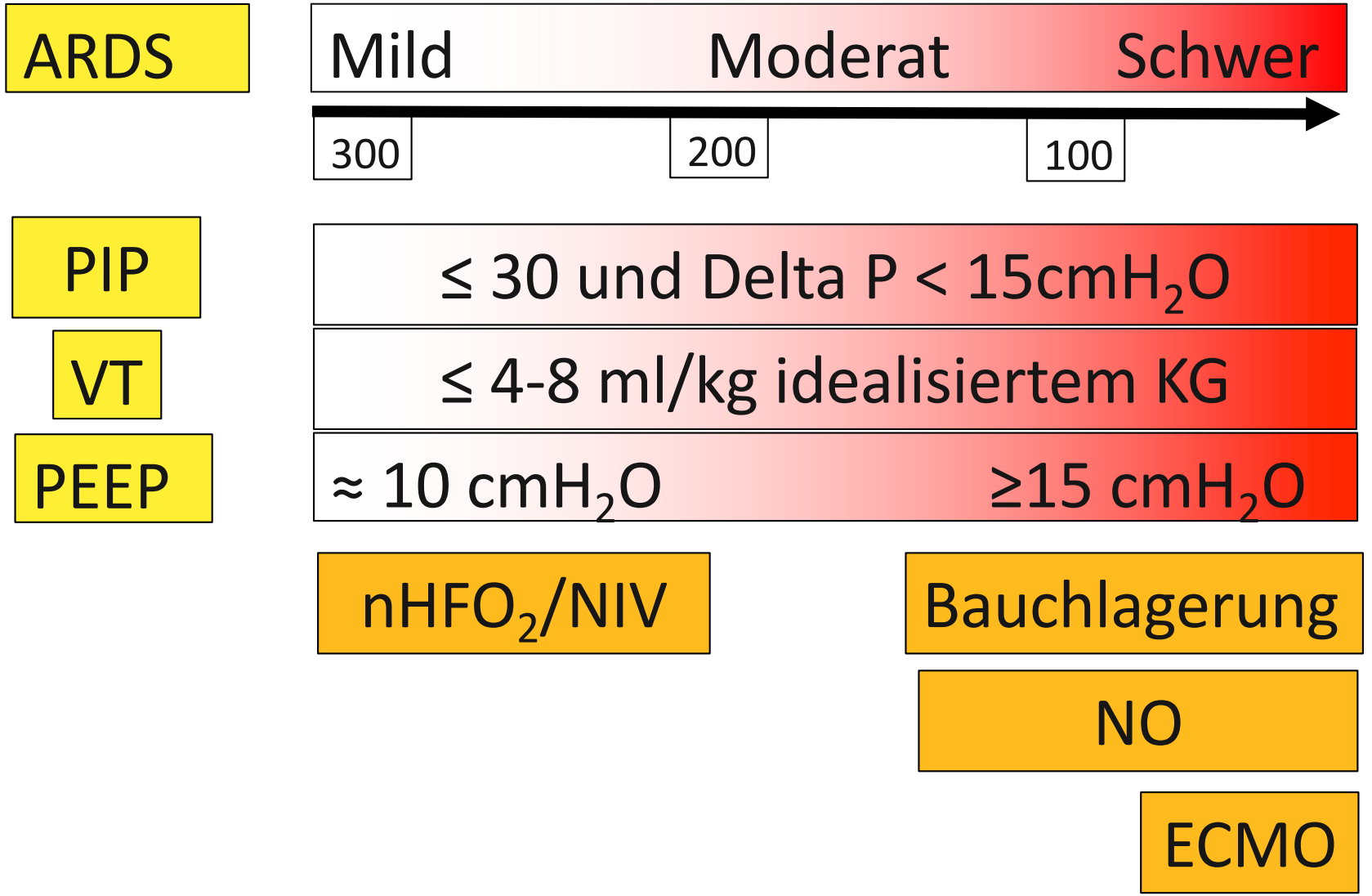
Deutschland ca. 2450 COVID-19-Patienten intensivmedizinisch in Behandlung

Versorgungsgebiet	COVID-19-Patienten im Krankenhaus (Verdacht und bestätigt)				
	Normal-pflegebetten	ITS/IMC mit Beatmung	ITS/IMC ohne Beatmung	Insgesamt	Anteil beatmete Patienten
VG Kassel	53	19	8	80	24%
VG Fulda-Bad Hersfeld	27	15	5	47	32%
VG Gießen-Marburg	84	39	5	128	30%
VG Frankfurt-Offenbach	291	111	23	425	26%
VG Wiesbaden-Limburg	39	13	13	65	20%
VG Darmstadt	84	26	6	116	22%
Hessen	**578**	**223**	**60**	**861**	**26%**

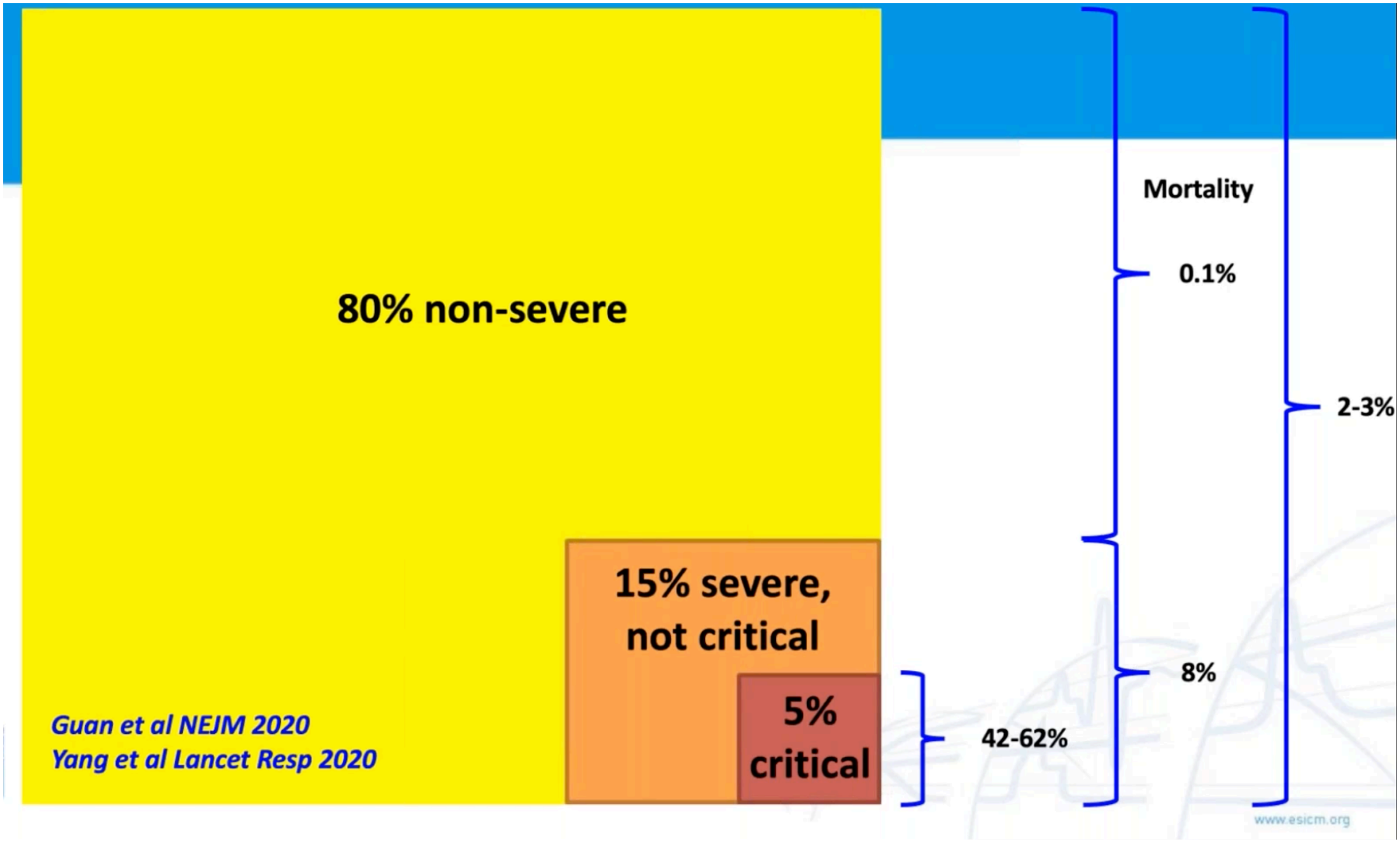
Versorgungsgebiet	Freie Betten			
	Normal-pflegebetten	ITS/IMC mit Beatmung	ITS/IMC ohne Beatmung	Insgesamt
VG Kassel	1.911	134	96	2.141
VG Fulda-Bad Hersfeld	1.440	72	50	1.562
VG Gießen-Marburg	1.954	159	84	2.197
VG Frankfurt-Offenbach	3.550	197	105	3.852
VG Wiesbaden-Limburg	1.103	102	29	1.234
VG Darmstadt	1.493	112	41	1.646
Hessen	**11.451**	**776**	**405**	**12.632**

IVENA-Hessen

Strategien bei COVID-19 Patienten mit akutem Lungenversagen (ARDS)



COVID-19 – Verlauf und Mortalität



Inzidenz ARDS in COVID-19-Patienten (China)

Table 1. Comparison of Outcomes in Patients with Coronavirus Disease (COVID-19) Infections

Cohort	Huang et al	Chen et al	Wang et al	Yang et al	Xu et al	Wu et al	Guan et al
Centre/s	Jin Yin Tan Hospital, Wuhan, China	Jin Yin Tan Hospital, Wuhan, China	Zhongnan Hospital, Wuhan, China	Jin Yin Tan Hospital, Wuhan, China	7 hospitals in Zhejiang, China	3 hospitals in Jiangsu, China	552 hospitals in 30 provinces, China
Period of hospitalisation/recruitment	16 Dec 2019 – 2 Jan 2020	1 Jan – 20 Jan 2020	1 Jan – 28 Jan 2020	24 Dec 2019 – 12 Jan 2020	10 Jan – 26 Jan 2020	22 Jan – 14 Feb 2020	11 Dec 2019 – 29 Jan 2020
Final follow-up date	22 Jan 2020	25 Jan 2020	3 Feb 2020	9 Feb 2020	26 Jan 2020	14 Feb 2020	31 Jan 2020
No. of patients	41	99	138	201	62	80	1099
Age, years*	49 (41 – 58)	56 (13)	56 (42 – 68)	–	41 (32 – 52)	46 (31 – 62)	47 (35 – 58)
Comorbidity							
Hypertension	15%	–	31%	–	8%	–	15%
Diabetes Mellitus	20%	–	10%	–	2%	–	7%
Cardiovascular disease	15%	40%	15%	–	–	–	3%
Cerebrovascular disease	–	–	5%	–	2%	–	1%
Chronic respiratory disease	2%	1%	3%	–	2%	1%	1%
Outcomes							
Admission to ICU	32%	23%	26%	27%	2%	0%	5%
ARDS	29%	17%	20%	17%	2%	0%	3%
Death	15%	11%	4%	17%	0%	0%	1%
Remain hospitalised at time of analysis	17%	58%	62%	6%	98%	76%	94%

Ken J Goh Singapore Med. 2020

Demographie, Symptome, Komorbiditäten und Radiologie – China

JAMA Internal Medicine | Original Investigation

Risk Factors Associated With Acute Respiratory Distress Syndrome and Death in Patients With Coronavirus Disease 2019 Pneumonia in Wuhan, China

Table 1. Demographic Characteristics of Patients With Coronavirus Disease 2019 Pneumonia

Study population	No. (%)
No. of patients	201
Age, median (IQR), y	51 (43-60)
≥65	40 (19.9)
<65	161 (80.1)
Highest patient temperature, median (IQR), °C	38.8 (38.3-39.0)
≥39 (high fever)	77 (38.3)
<39	93 (46.3)
Gender	
Male	128 (63.7)
Female	73 (36.3)
Initial common symptoms	
Fever	188 (93.5)
Cough	163 (81.1)
Productive cough	83 (41.3)
Dyspnea	80 (39.8)
Fatigue or myalgia	65 (32.3)
Chest imaging, infiltrate[a]	
Unilateral	10 (5.0)
Bilateral	191 (95.0)
Comorbidities	
Hypertension	39 (19.4)
Diabetes	22 (10.9)
Cardiovascular disease	8 (4.0)
Liver disease	7 (3.5)
Nervous system disease	7 (3.5)
Chronic lung disease	5 (2.5)
Chronic kidney disease	2 (1.0)
Endocrine system disease[b]	2 (1.0)
Tumor	1 (0.5)

Risikofaktoren für die Entwicklung eines ARDS / Versterben

JAMA Internal Medicine | Original Investigation

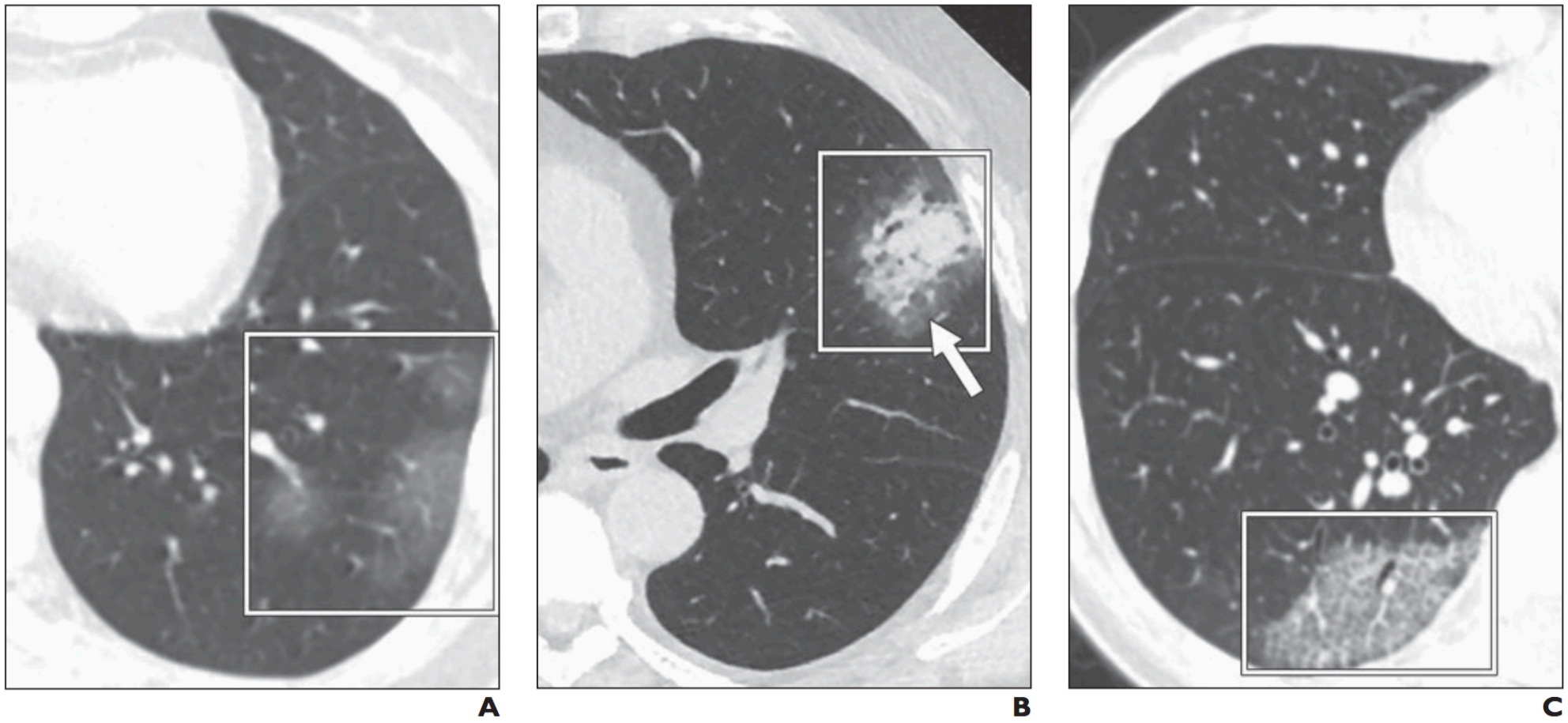
Risk Factors Associated With Acute Respiratory Distress Syndrome and Death in Patients With Coronavirus Disease 2019 Pneumonia in Wuhan, China

Table 4. Bivariate Cox Regression of Factors Associated With ARDS Development or Progression From ARDS to Death

	ARDS		Death	
Patient characteristics and findings	HR (95% CI)	*P* value	HR (95% CI)	*P* value
Clinical characteristics				
Age (≥65 vs <65), y	3.26 (2.08-5.11)	<.001	6.17 (3.26-11.67)	<.001
Highest patient temperature (≥39 °C vs <39 °C)	1.77 (1.11-2.84)	.02	0.41 (0.21-0.82)	.01
Hematologic				
Neutrophils, 10^9/mL	1.14 (1.09-1.19)	<.001	1.08 (1.01-1.17)	.03
Biochemical				
Total bilirubin, mg/dL	1.05 (1.02-1.08)	.001	1.07 (1.02-1.12)	.003
Urea, mM	1.13 (1.09-1.18)	<.001	1.13 (1.06-1.20)	<.001
LDH, 100 U/L	1.61 (1.44-1.79)	<.001	1.30 (1.11-1.52)	.001
IL-6, pg/L	1.02 (1.00-1.05)	.09	1.03 (1.01-1.05)	.01
D-dimer, μg/mL	1.03 (1.01-1.04)	<.001	1.02 (1.01-1.04)	.002

COVID-19 - Radiologie

CT Features of Coronavirus Disease 2019 (COVID-19) Pneumonia in 62 Patients in Wuhan, China



Milchglastrübungen

Milchglastrübungen + Konsolidierungen

Milchglastrübungen + Retikuläres Bild

COVID-19 - Radiologie

RESEARCH ARTICLE

Association of radiologic findings with mortality of patients infected with 2019 novel coronavirus in Wuhan, China

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* Huyi_pub@163.com

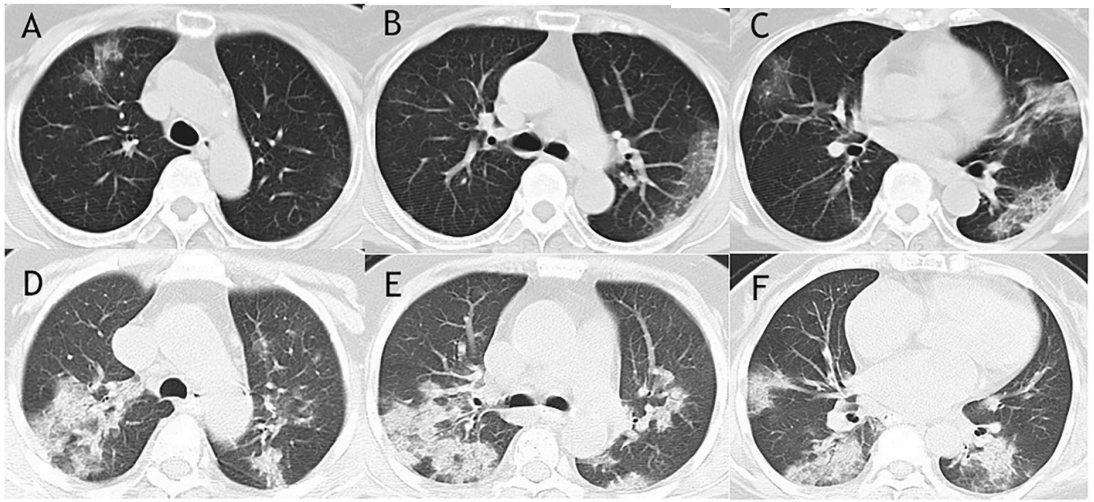
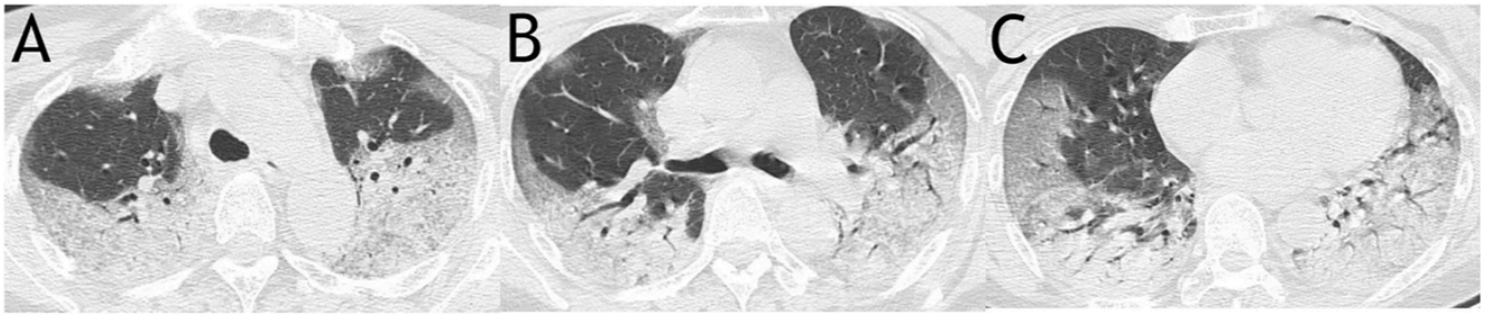
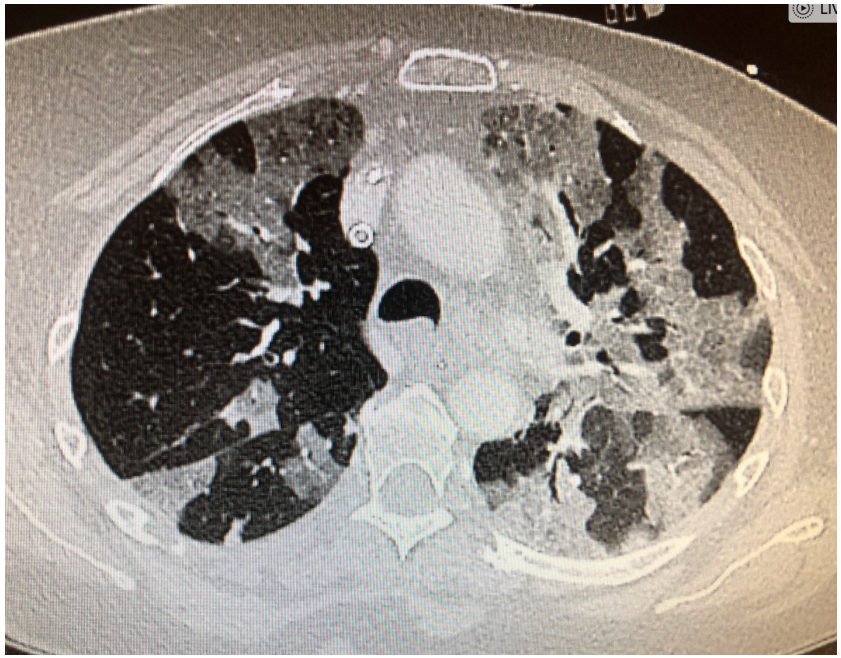
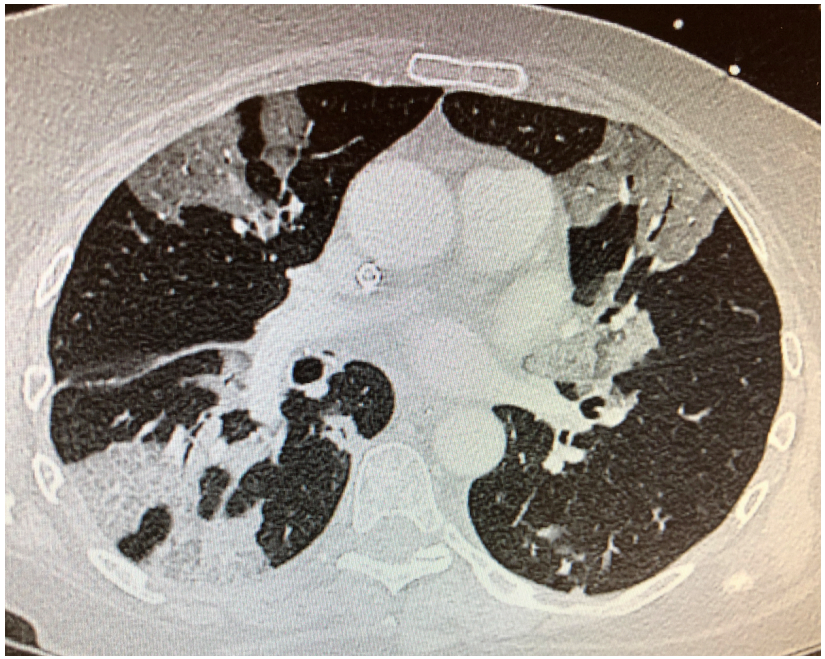


Fig 2. Comparison of CT images between survival group and mortality group. CT images of a 76-year-old woman from survival group showed pure ground glass opacities with predominant peripheral distribution in middle and lower lung zones (A-C). Air bronchogram, together with extensive of consolidations and ground glass opacities were found in the CT images of a 72–year-old woman from mortality group (D-F).



COVID-19 – Radiologie





50 Jahre, weiblich, keine wesentlichen VE
Klinikum Kassel

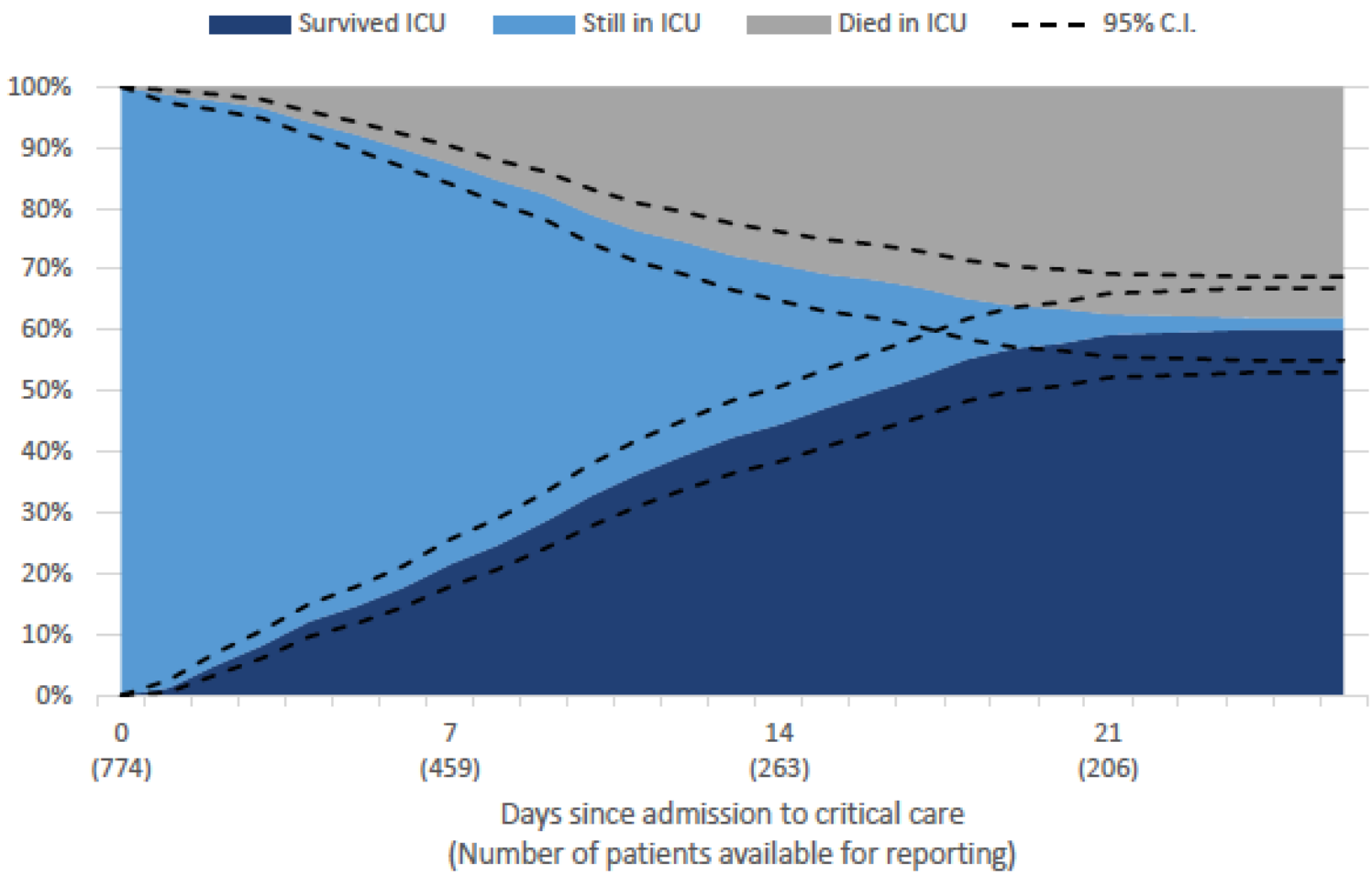
Komplikationen und Therapie

	Total (N=138)	ICU (n-36)	Non-ICU (n=102)	*P* Value
Shock	12 (9)	11 (31)	1 (1)	<.001
Acute cardiac injury	10 (7)	8 (22)	2 (2)	<.001
Arrhythmia	23 (17)	16 (44)	7 (7)	<.001
ARDS	27 (20)	22 (61)	5 (5)	<.001
AKI	5 (4)	3 (8)	2 (2)	.11

	Total (N=138)	ICU (n-36)	Non-ICU (n=102)	*P* Value
Antiviral therapy	124 (89)	34 (94)	90 (88)	.36
Glucocorticoids	62 (45)	26 (72)	36 (35)	<.001
CKRT	2 (1)	2 (5)	0	>.99
Oxygen inhalation	106 (77)	4 (11)	102 (100)	<.001
NIV	15 (11)	15 (42)	0	<.001
IMV	17 (12)	17 (47)	0	<.001
ECMO	4 (3)	4 (11)	0	.004

Wang et al JAMA 2020

Outcome (UK)

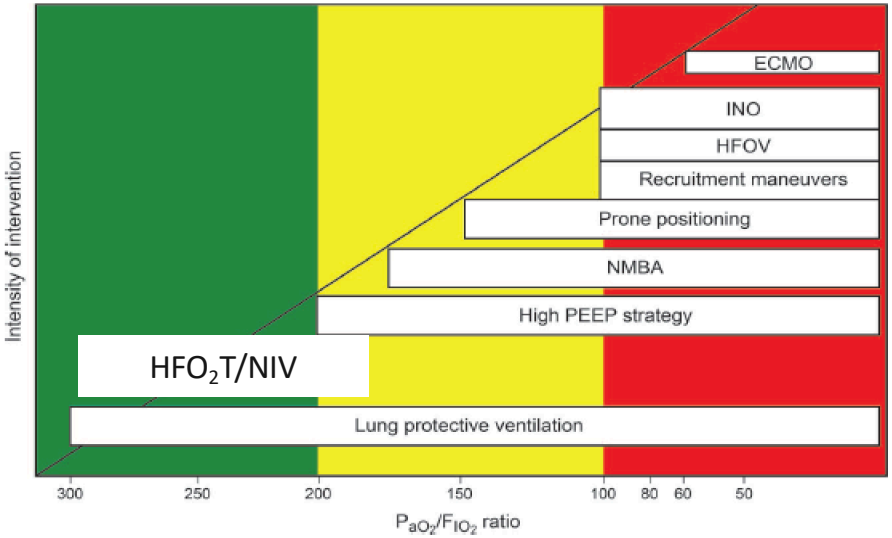


ca. 50%
der Pat.
verstorben

n=165

Nicht-invasive Beatmung und High-flow O_2 –Therapie (HFOT)

- NIV mit Stellenwert bei hyperkapnisch ass. Resp. Insuff.
- NIV kann bei leichtem bis „mildem“ ARDS (hypoxämisch) eingesetzt werden (Zentren mit Erfahrung)
- ➢ NIV Versagen bis 85% bei H1N1-Pat.
- ➢ Reduktion der ITN-Frequenz



– HFO_2-T (HFOT) konnte in einem kleinen Patientenkollektiv mit H1N1-assoziiertem ARDS erfolgreich zur Vermeidung einer ITN eingesetzt werden. Bei schweren Verläufen mussten die Pat. intubiert werden.

S3-LL-NIV
Kumar et al. JAMA 2009
Rello et al. J Crit Care 2012

Transmission nosokomial

- Daten aus China:
  - Nosokomiale Übertragung bei ca. 41 % der Patienten
  - Bis zu 29% des Krankenhauspersonals

COVID-19-ITS Klinikum Kassel

S3-LL-NIV
Wang JAMA 2020

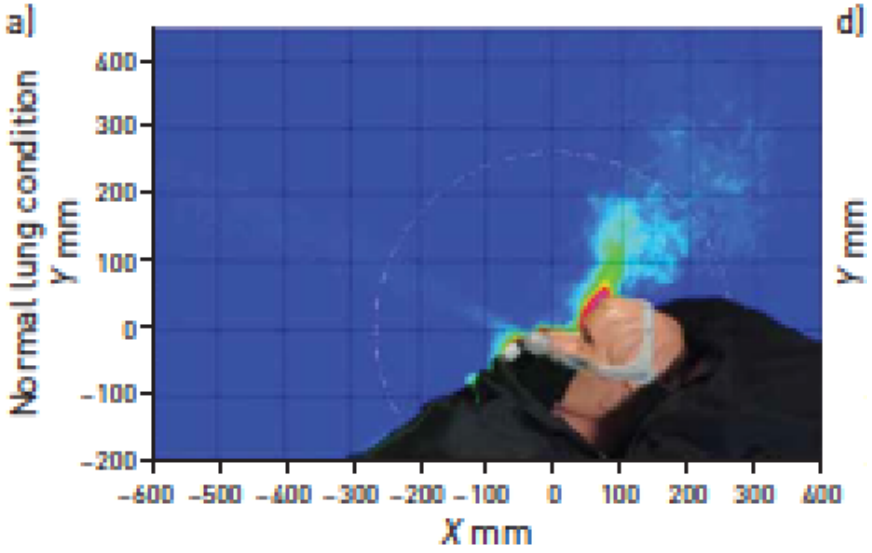
Transmission nosokomial – Leakage NIV

Komplikationen und klinische Aspekte	Invasive Beatmung	Nichtinvasive Beatmung
Ventilator-(Tubus-) assoziierte Pneumonie	Anstieg des Risikos ab dem 3. – 4. Tag der Beatmung	Selten
Tubusbedingte zusätzliche Atemarbeit	Ja (während Spontanatmung und im Falle assistierender Beatmung)	Nein
Tracheale Früh-und Spätschäden	Ja	Nein
Sedierung	Häufig tief oder moderat	Nein oder mild
Intermittierende Applikation	Selten möglich	Häufig möglich
Effektives Husten möglich	Nein	Ja
Essen und Trinken möglich	Erschwert (Tracheostoma) bzw. Nein (Intubation)	Ja
Kommunikation möglich	Erschwert	Ja
Zugang zu den Atemwegen	Direkt	Erschwert
Druckstellen im Gesichtsbereich	Nein	Mit Anwendungsdauer zunehmend
CO2-Rückatmung	Nein	Beim Beatmungshelm
Leckage	Selten	Häufig
Aerophagie	Sehr selten	Häufiger

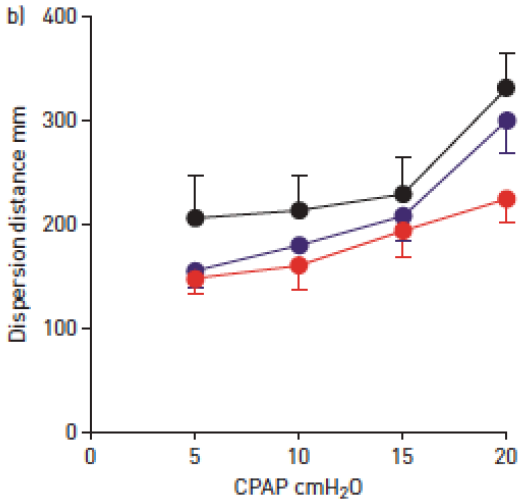
S3-LL-NIV

Transmission nosokomial – Dispersion bei NIV und High-Flow O_2

- Während nasaler high-flow O_2 –Therapie + Nicht-invasiver Beatmung (NIV) kommt es insbesondere bei höheren Flows und CPAP-Drücken zu einer Zerstreuung von Teilchen bis zu 30-40 cm
- NIV bei SARS-Pat. fragliche Transmission!



Cheung et al. Chest 2004
Hui DSChow Eur Respir J 2019



Surviving Sepsis Campaign und COVID-19 – O_2-Gabe

- Die Prävalenz eines „Hypoxämischen respiratorischen Versagens (Partialinsuffizienz)“ bei COVID-19 Patienten ist ca. 19%.

- N=1009 COVID-19 Patienten in China
  - ➢ 41% aller hospitalisierten Patienten und über 70% mit schwerer Erkrankung benötigten einen O_2-Therapie.

Recommendations:

23. In adults with COVID-19, we **suggest** starting supplemental oxygen if the peripheral oxygen saturation (SPO_2) is < 92% (weak recommendation, low quality evidence), and **recommend** starting supplemental oxygen if SPO_2 is < 90% (strong recommendation, moderate quality evidence).

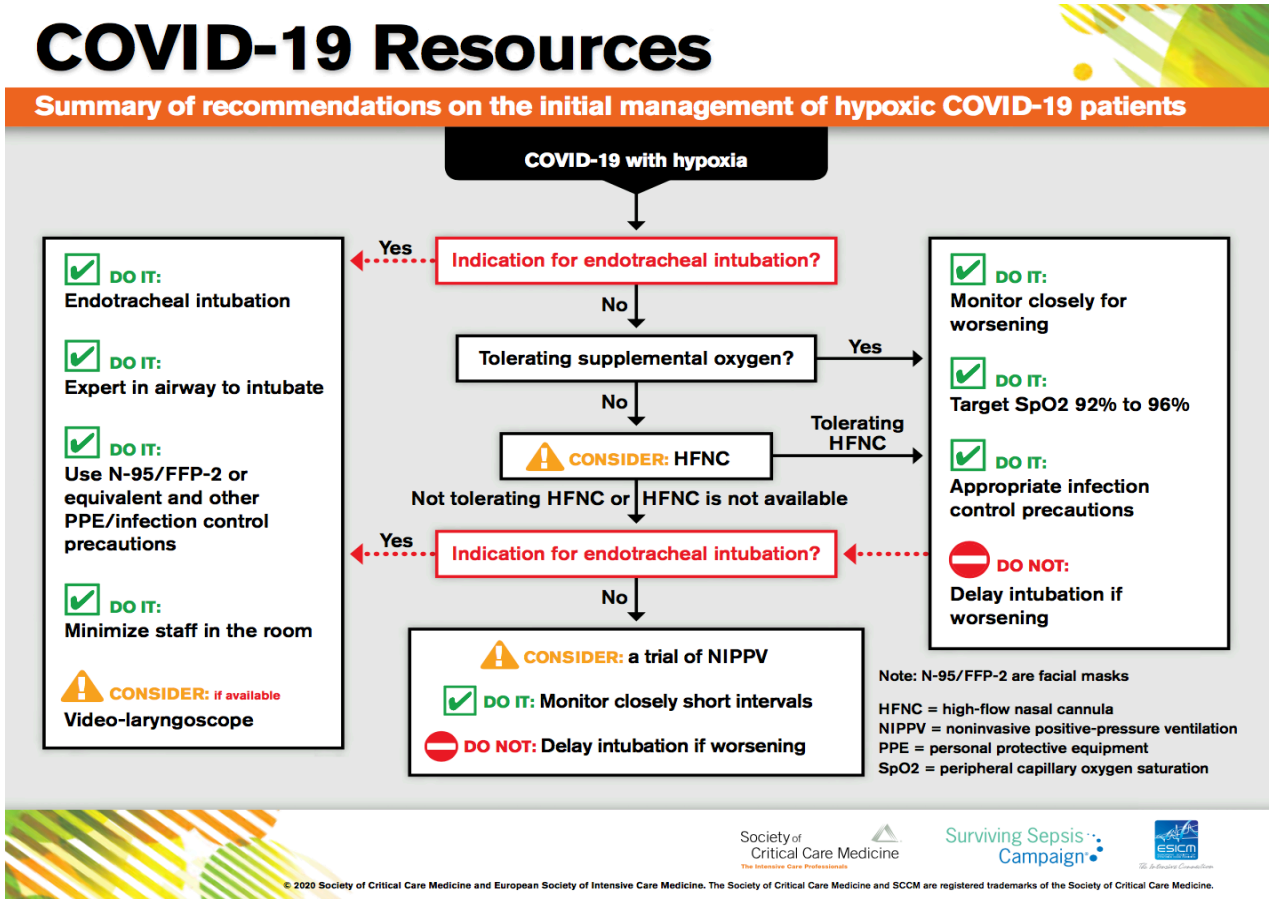
24. In adults with COVID-19 and **acute hypoxemic respiratory failure on oxygen**, we **recommend** that SPO_2 be maintained no higher than 96% (strong recommendation, moderate quality evidence).

Surviving Sepsis Campaign

Surviving Sepsis Campaign und COVID-19 – NIV vs. High-Flow O_2

Recommendation:

26. In adults with COVID-19 and **acute hypoxemic respiratory failure**, we **suggest** using HFNC over NIPPV (weak recommendation, low quality evidence).



Surviving Sepsis Campaign

Surviving Sepsis Campaign und COVID-19 – NIV vs. High-Flow O_2

Recommendations:

27. In adults with COVID-19 and **acute hypoxemic respiratory failure**, if HFNC is not available and there is no urgent indication for endotracheal intubation, we **suggest** a trial of NIPPV with close monitoring and short-interval assessment for worsening of respiratory failure (weak recommendation, very low-quality evidence).

28. **We were not able to make a recommendation** regarding the use of helmet NIPPV compared with mask NIPPV. It is an option, but we are not certain about its safety or efficacy in COVID-19.

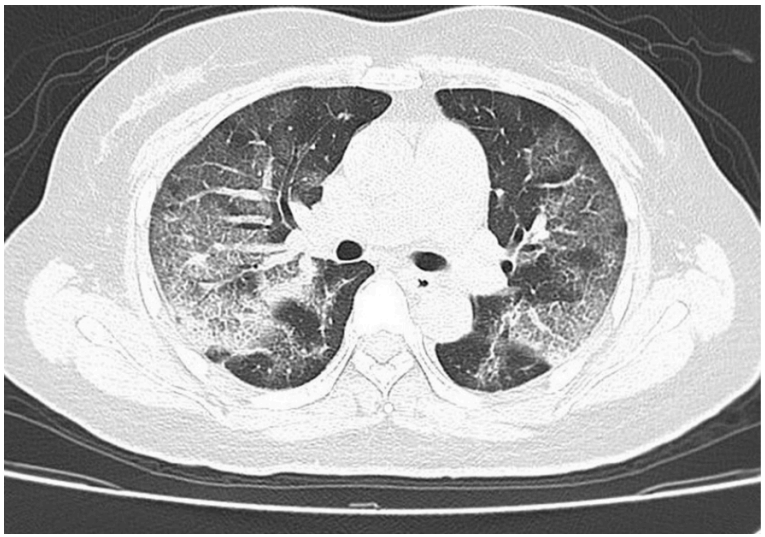
29. In adults with COVID-19 receiving NIPPV or HFNC, we **recommend** close monitoring for worsening of respiratory status, and early intubation in a controlled setting if worsening occurs (best practice statement).

Surviving Sepsis Campaign

Was sind die pathophysiologischen Besonderheiten des COVID-19-(ARDS)-Patienten?

1. Lungen-Compliance „normal“:
   - ➢ Kaum dorsale Konsolidierungen
   - ➢ Fehlende Rekrutierung nicht das Problem!

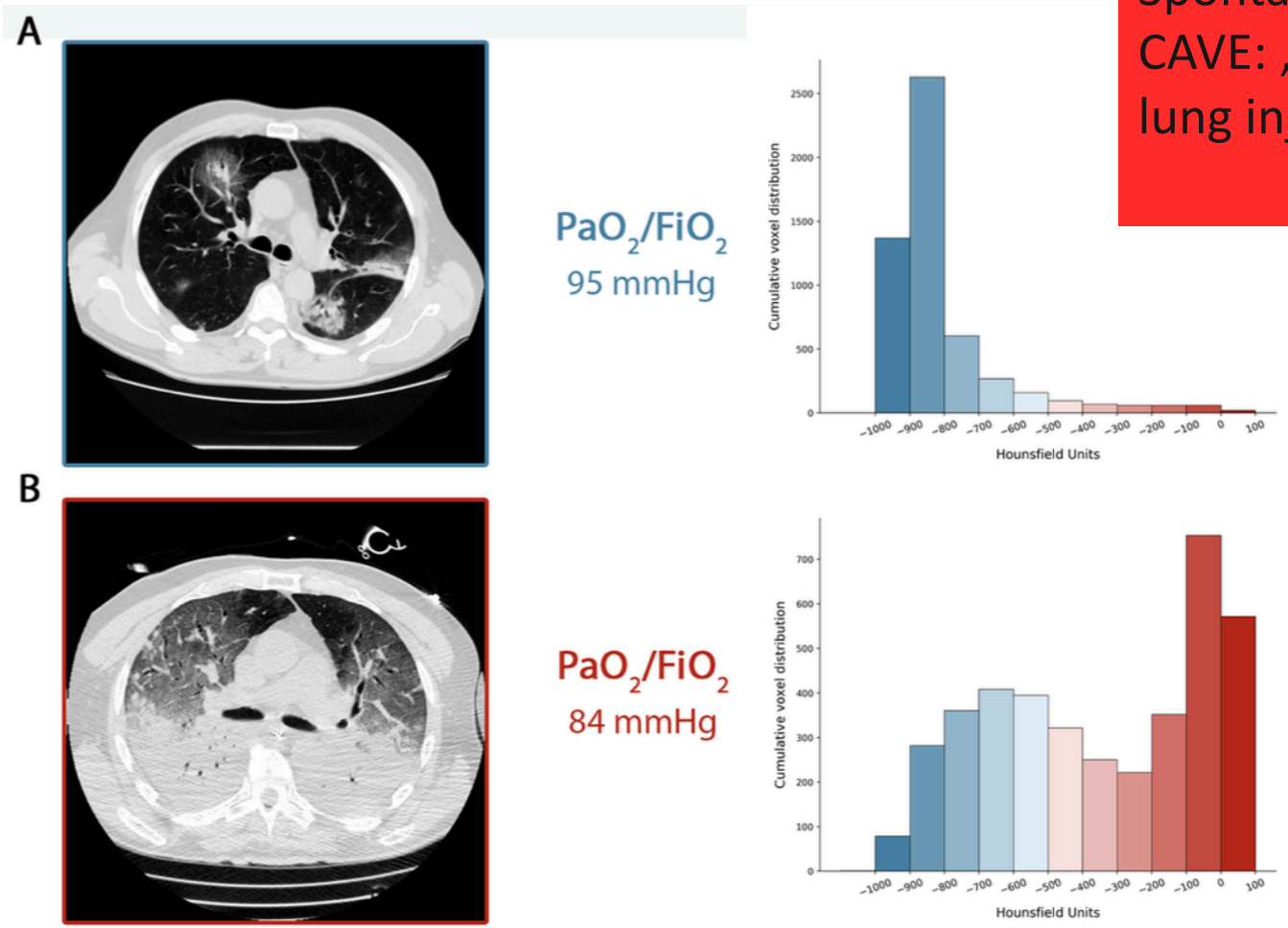
2. Schwere Oxygenierungsstörung:
   a. Perfusionsstörung (Va/Q-Mismatch, Shunt > 50%)
   b. Hypoxisch pulmonale Vasokonstriktion



ERJ 2020

Was sind die pathophysiologischen Besonderheiten des COVID-19-(ARDS)-Patienten?

Spontanatmung:
CAVE: „self induced lung injury“



Gattinoni L ICM 2020

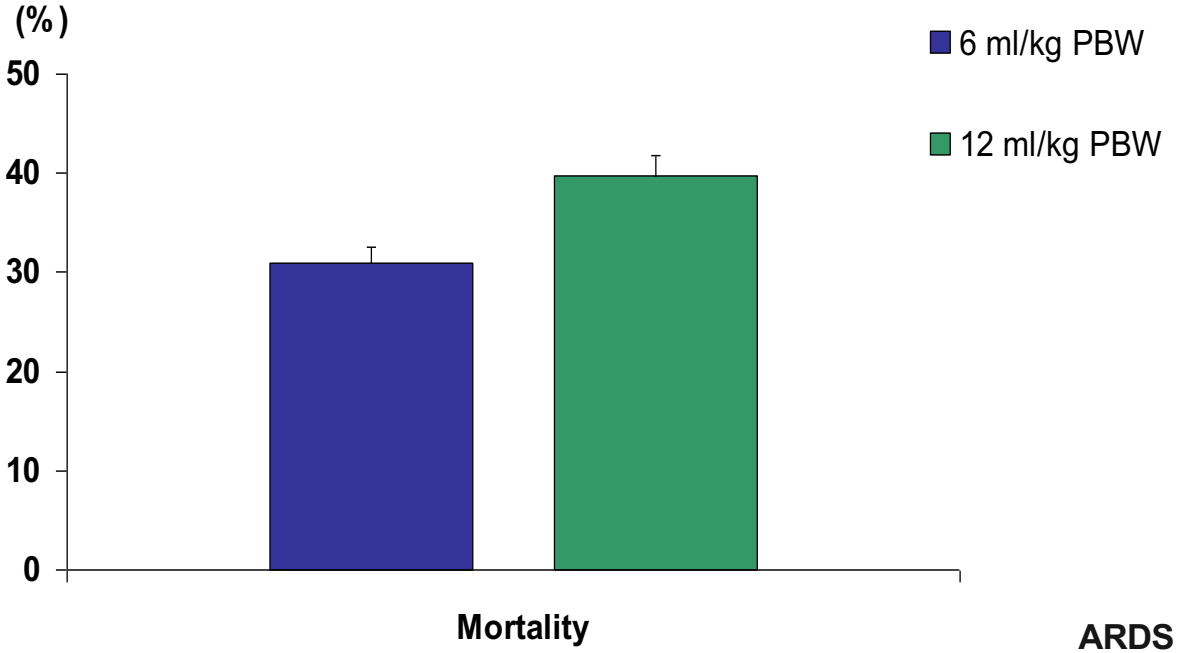
Surviving Sepsis Campaign und COVID-19 – Tidalvolumen (VT)

Recommendation:

30. In mechanically ventilated adults with COVID-19 and ARDS, we **recommend** using low tidal volume (Vt) ventilation (Vt 4-8 mL/kg of predicted body weight), over higher tidal volumes (Vt>8 mL/kg) (strong recommendation, moderate quality evidence).

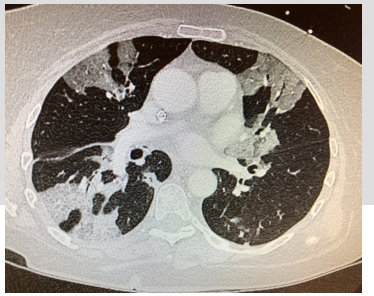
Recommendation:

31. For mechanically ventilated adults with COVID-19 and **ARDS**, we **recommend** targeting plateau pressures (Pplat) of < 30 cm H_2O (strong recommendation, moderate quality evidence).



ARDS Network NEJM 2000

Surviving Sepsis Campaign und COVID-19 – PEEP



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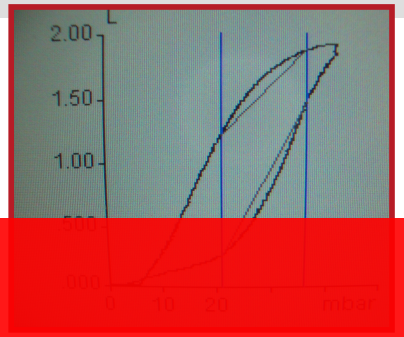


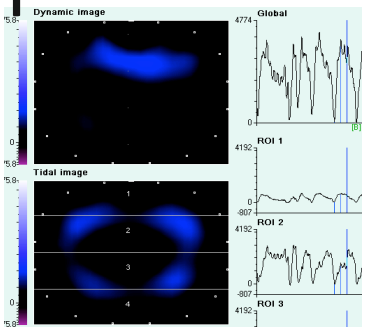
FiO_2	(	0,9	1,0
PEEP	5	18	18-24

Recommendation:

32. For mechanically ventilated adults with COVID-19 and moderate to severe ARDS, we **suggest** using a higher PEEP strategy, over a lower PEEP strategy (weak recommendation, low quality evidence).

Decremental PEEP-Trial

EIT



Daten aus Italien – ESICM Vortrag (Pesenti) – PEEP beim italienischen COVID-Kollektiv

- n= 672
- ***PEEP:***
  - Max. 22 cmH2O
  - 75 % Perzentile 15
  - Median 14
  - 25% Perzentile 12
  - Mittel 13 +/- 3

Recommendation:

32. For mechanically ventilated adults with COVID-19 and moderate to severe ARDS, we **suggest** using a higher PEEP strategy, over a lower PEEP strategy (weak recommendation, low quality evidence).

ESICM Vortrag

Surviving Sepsis Campaign und COVID-19 – restriktive / konservative Flüssigkeitstherapie

Recommendation:

33. For mechanically ventilated adults with COVID-19 and ARDS, we **suggest** using a conservative fluid strategy over a liberal fluid strategy (weak recommendation, low quality evidence).

- Leitsatz „Keep the lung dry“

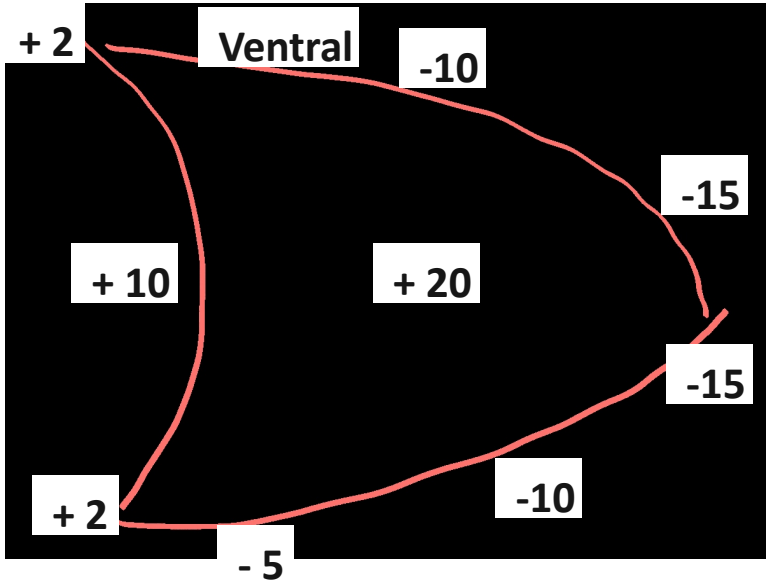
Sporn P AAS Suppl 1996
Schuster DP ICM 1995

Surviving Sepsis Campaign und COVID-19 – Bauchlagerungstherapie

Recommendation:

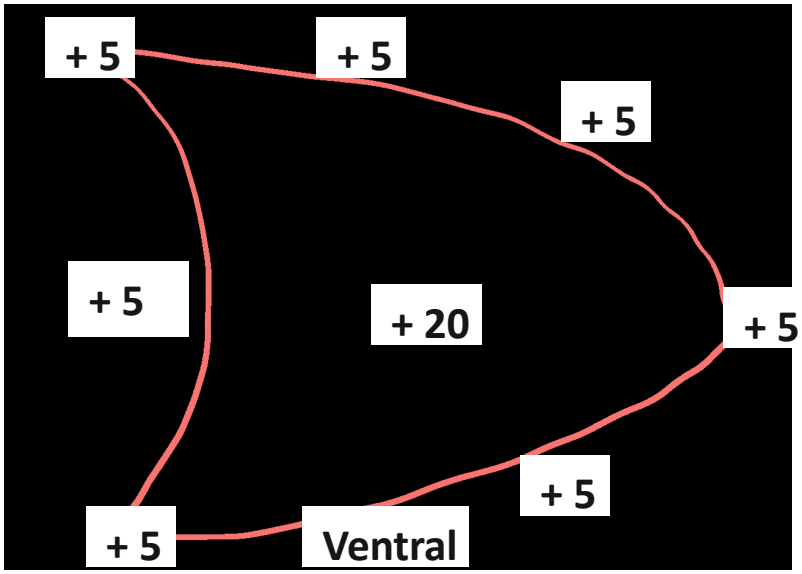
34. For mechanically ventilated adults with COVID-19 and **moderate to severe ARDS**, we **suggest** prone ventilation for **12 to 16 hours**, over no prone ventilation (weak recommendation, low quality evidence).

Rückenlage



Inhomoge Verteilung des Pleuradruckes

Bauchlage



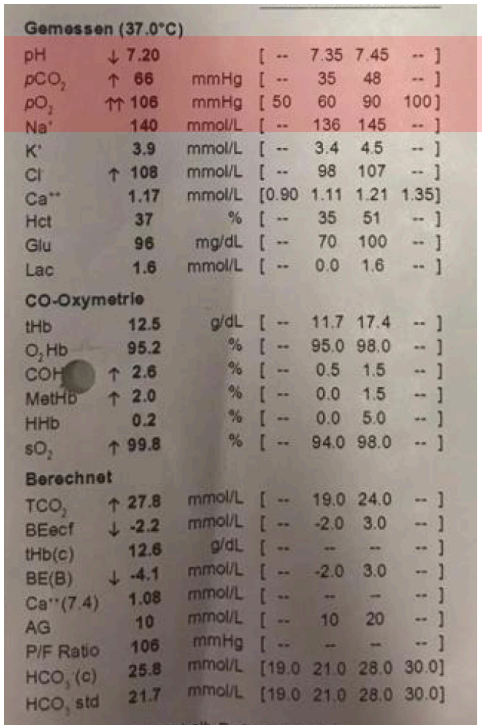
Homogenisierung des Pleuradruckes

Surviving Sepsis Campaign und COVID-19 – Inhalative Vasoldilatation (NO-Therapie)

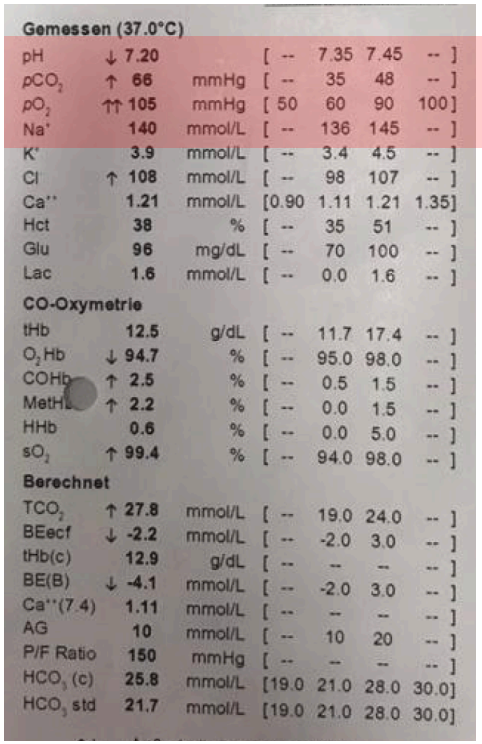
Recommendations:

36. In mechanically ventilated adults with COVID-19 ARDS, we **recommend against** the routine use of inhaled nitric oxide (strong recommendation, low quality evidence).

37. In mechanically ventilated adults with COVID-19, severe ARDS and hypoxemia despite optimizing ventilation and other rescue strategies, we **suggest** a trial of inhaled pulmonary vasodilator as a rescue therapy; if no rapid improvement in oxygenation is observed, the treatment should be tapered off (weak recommendation, very low quality evidence).



Gemessen (37.0°C)						
pH	↓ 7.20		[--	7.35	7.45	--]
pCO_2	↑ 66	mmHg	[--	35	48	--]
pO_2	↑↑ 106	mmHg	[50	60	90	100]
Na^+	140	mmol/L	[--	136	145	--]
K^+	3.9	mmol/L	[--	3.4	4.5	--]
Cl	↑ 108	mmol/L	[--	98	107	--]
Ca^{++}	1.17	mmol/L	[0.90	1.11	1.21	1.35]
Hct	37	%	[--	35	51	--]
Glu	96	mg/dL	[--	70	100	--]
Lac	1.6	mmol/L	[--	0.0	1.6	--]
CO-Oxymetrie						
tHb	12.5	g/dL	[--	11.7	17.4	--]
O_2Hb	95.2	%	[--	95.0	98.0	--]
COHb	↑ 2.6	%	[--	0.5	1.5	--]
MetHb	↑ 2.0	%	[--	0.0	1.5	--]
HHb	0.2	%	[--	0.0	5.0	--]
sO_2	↑ 99.8	%	[--	94.0	98.0	--]
Berechnet						
TCO_2	↑ 27.8	mmol/L	[--	19.0	24.0	--]
BEecf	↓ -2.2	mmol/L	[--	-2.0	3.0	--]
tHb(c)	12.6	g/dL	[--	--	--	--]
BE(B)	↓ -4.1	mmol/L	[--	-2.0	3.0	--]
Ca^{++}(7.4)	1.08	mmol/L	[--	--	--	--]
AG	10	mmol/L	[--	10	20	--]
P/F Ratio	106	mmHg	[--	--	--	--]
HCO_3 (c)	25.8	mmol/L	[19.0	21.0	28.0	30.0]
HCO_3 std	21.7	mmol/L	[19.0	21.0	28.0	30.0]



Gemessen (37.0°C)						
pH	↓ 7.20		[--	7.35	7.45	--]
pCO_2	↑ 66	mmHg	[--	35	48	--]
pO_2	↑↑ 105	mmHg	[50	60	90	100]
Na^+	140	mmol/L	[--	136	145	--]
K^+	3.9	mmol/L	[--	3.4	4.5	--]
Cl	↑ 108	mmol/L	[--	98	107	--]
Ca^{++}	1.21	mmol/L	[0.90	1.11	1.21	1.35]
Hct	38	%	[--	35	51	--]
Glu	96	mg/dL	[--	70	100	--]
Lac	1.6	mmol/L	[--	0.0	1.6	--]
CO-Oxymetrie						
tHb	12.5	g/dL	[--	11.7	17.4	--]
O_2Hb	↓ 94.7	%	[--	95.0	98.0	--]
COHb	↑ 2.5	%	[--	0.5	1.5	--]
MetHb	↑ 2.2	%	[--	0.0	1.5	--]
HHb	0.6	%	[--	0.0	5.0	--]
sO_2	↑ 99.4	%	[--	94.0	98.0	--]
Berechnet						
TCO_2	↑ 27.8	mmol/L	[--	19.0	24.0	--]
BEecf	↓ -2.2	mmol/L	[--	-2.0	3.0	--]
tHb(c)	12.9	g/dL	[--	--	--	--]
BE(B)	↓ -4.1	mmol/L	[--	-2.0	3.0	--]
Ca^{++}(7.4)	1.11	mmol/L	[--	--	--	--]
AG	10	mmol/L	[--	10	20	--]
P/F Ratio	150	mmHg	[--	--	--	--]
HCO_3 (c)	25.8	mmol/L	[19.0	21.0	28.0	30.0]
HCO_3 std	21.7	mmol/L	[19.0	21.0	28.0	30.0]

20 ppm NO

R/L-Shunt
Ca. 40 %

Surviving Sepsis Campaign und COVID-19

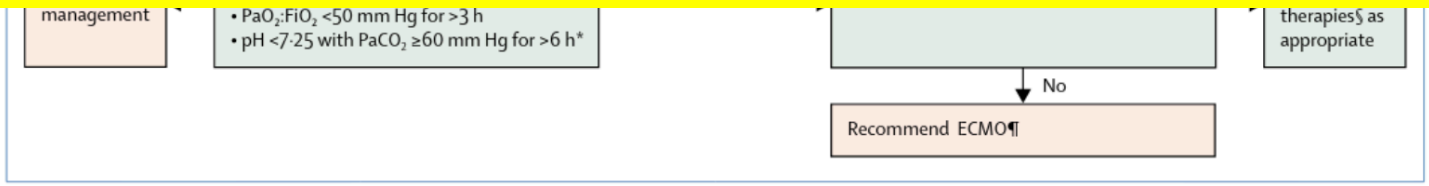
Recommendation:

40. In mechanically ventilated adults with COVID-19 and refractory hypoxemia despite optimizing ventilation, use of rescue therapies, and proning, we **suggest** using venovenous (VV) ECMO if

ELSO recommends against starting new ECMO centers for the sole purpose of treating patients with COVID-19.

"ECMO is not a therapy to be rushed to the front lines when all resources are stretched during a pandemic."

JAMA 2020



ELSO Guidelines

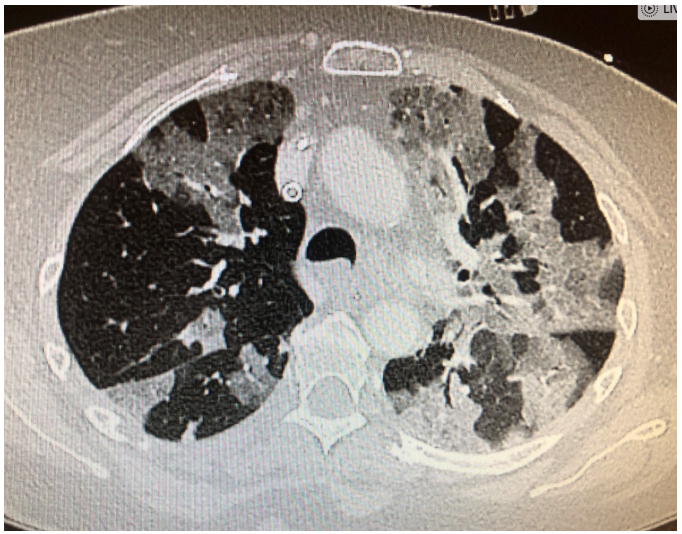
Zusammenfassung

Schwere Gasaustausch-störung

Rescueverfahren:
NO
ECMO

„Keep the lung dry“

Hoher PEEP ggf. Kontraproduktiv (Perfusion ↓)



Pathophysiologie:
- Inflammation
- Va/Q mismatch
- „recruitability↓“

HFO_2> NIV:
CAVE:
– Mitarbeiterschutz!
– „Self induced lung injury“

Lungenprotektiven Beatmung,
- ***6-8*** statt 4 ml/kg IBW

Bedanken möchte ich mich schon jetzt!

Vielen Dank für die Aufmerksamkeit

Zentrum Klinikum Kassel

Klinikum Kassel