

BEST PRACTICE

FÜR DAS KIND AUF DER INTENSIVSTATION

PICU Graz



Netzwerktreffen der österreichischen PICUS
11-12. November 2022

HFOV

High Frequency Oscillatory Ventilation

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Outline



- Mechanismus HFOV
- Literatur Dilemma
- HFOV/ Jet p-BLV Setup/Anwendung



To be continued...

1973



Barotrauma

1988



Volutrauma

1997



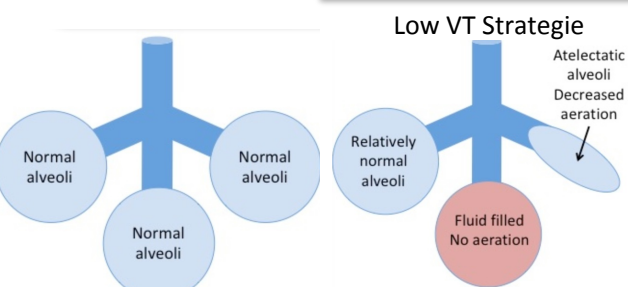
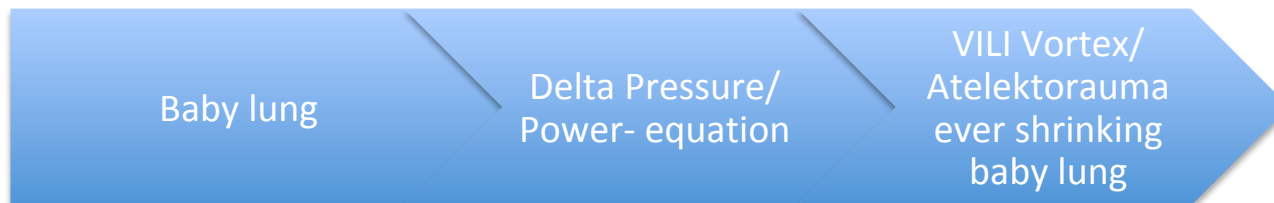
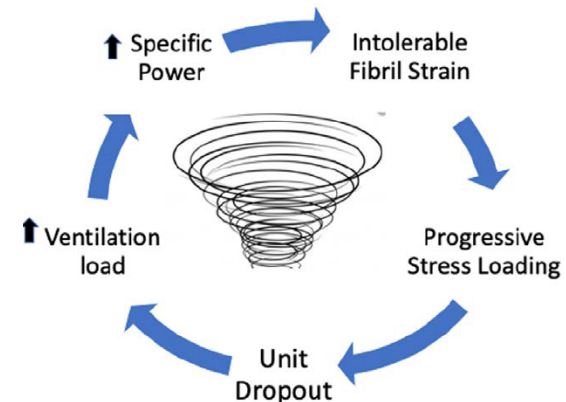
Atelectrauma
(Biotrauma)

Rheology &
Materials Engineering

2016



Ergotrauma



Compliance abhängig low VT Strategie

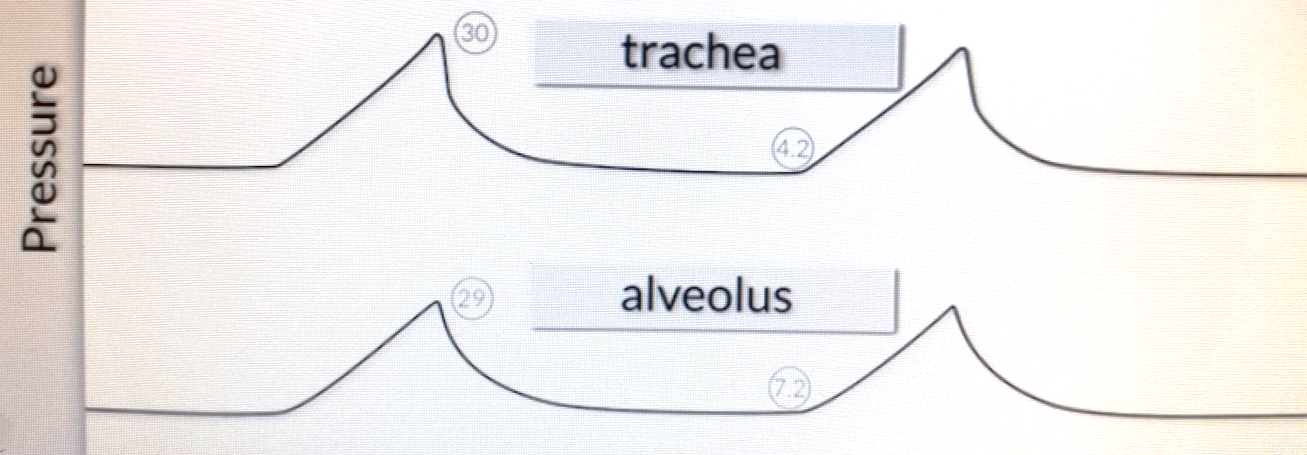
Viscoelastischer Körper
Stress/ Strain

			MECHANICAL POWER (J/MIN)					} X Conversion factor
			Power of inspiration (cmH ₂ O·L/min)					
			Work of inspiration (cmH ₂ O·L)					
			Volume (L) X	Pressure (cmH ₂ O)			} X Rate (bpm)	
				Elastic static component	+ Elastic dynamic component	+ Resistive component		
VCV	Extended equation	Gattinoni et al	ΔV	PEEP	$\Delta V \cdot \frac{1}{2} EL_{rs}$	$RR \cdot \frac{(1 + I:E)}{(60 \cdot I:E)} \cdot R_{aw}$	RR	0,098
	Simplified equation	Gattinoni et al	ΔV	$Peak\ Pressure - \frac{(Plateau\ Pressure - PEEP)}{2}$			RR	0,098
	Surrogate	Gloss et al	ΔV	$\frac{Peak\ Pressure + PEEP + F/6}{2}$			RR	0,1
PCV	Extended equation	Van der Meijden et al	ΔV	PEEP	$P_{insp} \cdot \left(1 - e^{-\frac{T_{insp}}{\tau}}\right)$		RR	0,098
		Becher et al	$(PEEP + P_{insp}) \cdot \Delta V - P_{insp}^2 \cdot C \cdot \left(0.5 - \left(\frac{R \cdot C}{T_{slope}}\right) + \left(\frac{R \cdot C}{T_{slope}}\right)^2 \cdot \left(1 - e^{-\frac{T_{slope}}{R \cdot C}}\right)\right)$				RR	0,098
	Surrogate	Becher et al	ΔV	PEEP	P_{insp}		RR	0,098

$$\text{Stress} = \frac{f}{dS} \text{ (N/m}^2\text{)} = \Delta P_{TP} = \text{cmH}_2\text{O}$$

$$\text{Strain rate} = \frac{\frac{dX - dX_0}{dt}}{dX_0} = \frac{\frac{\Delta V}{t}}{V_0}$$

Pressure Tracing in Conventional Mechanical Ventilation

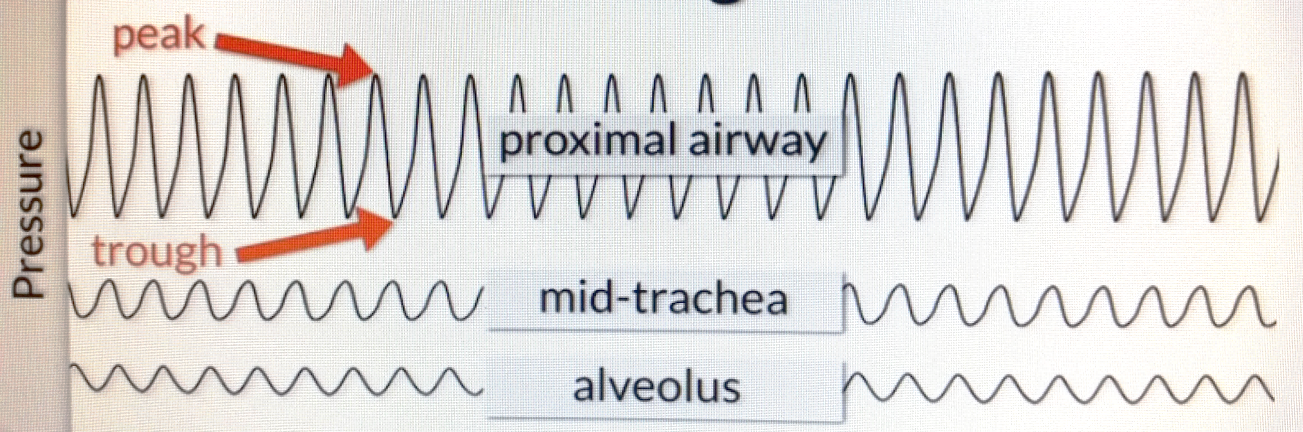


VT 4- 10 ml/kg

CO₂ Clearance = RR+*VT

AF je nach Altersgruppe und Modus

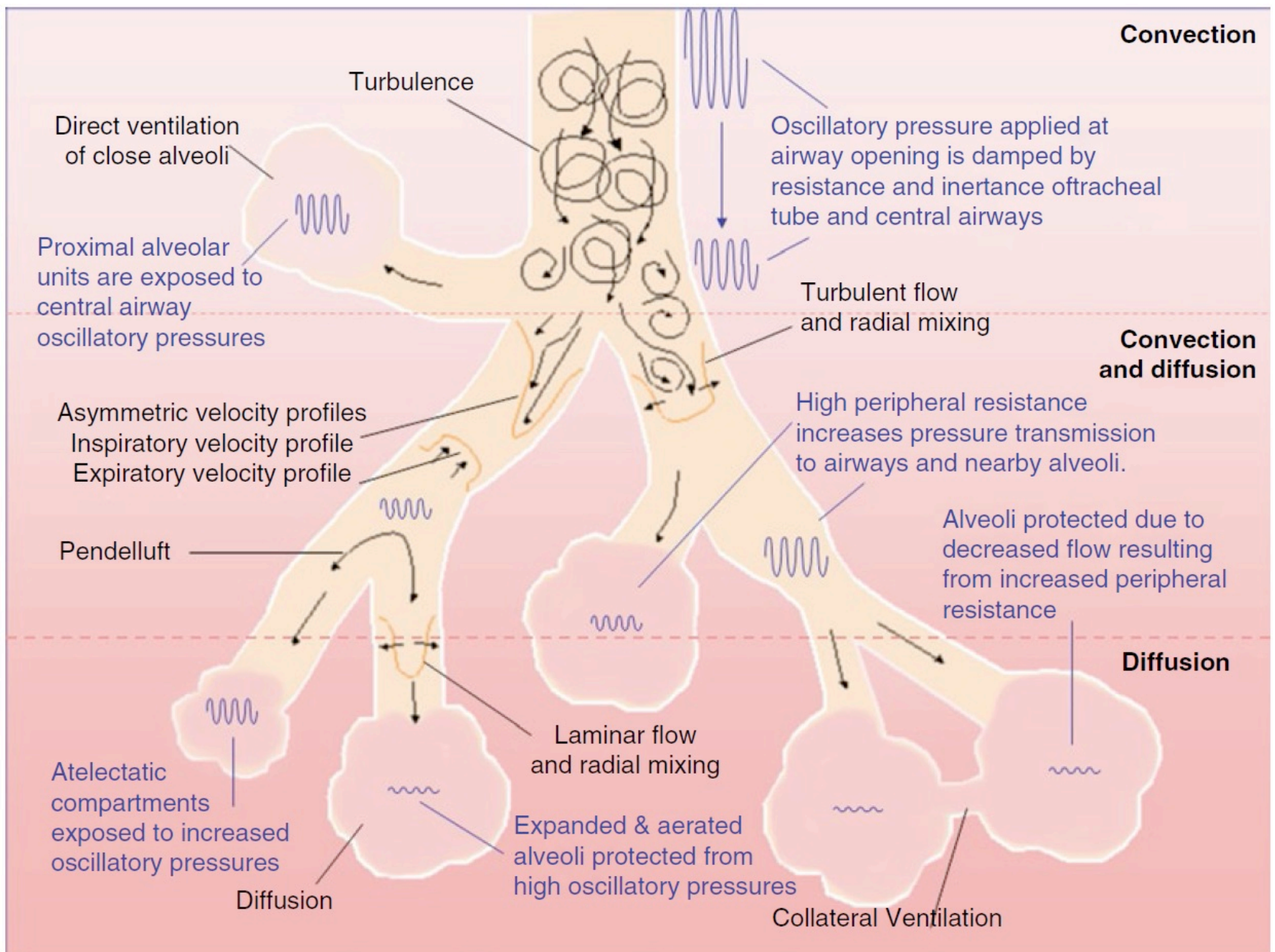
Pressure Tracings for HFOV



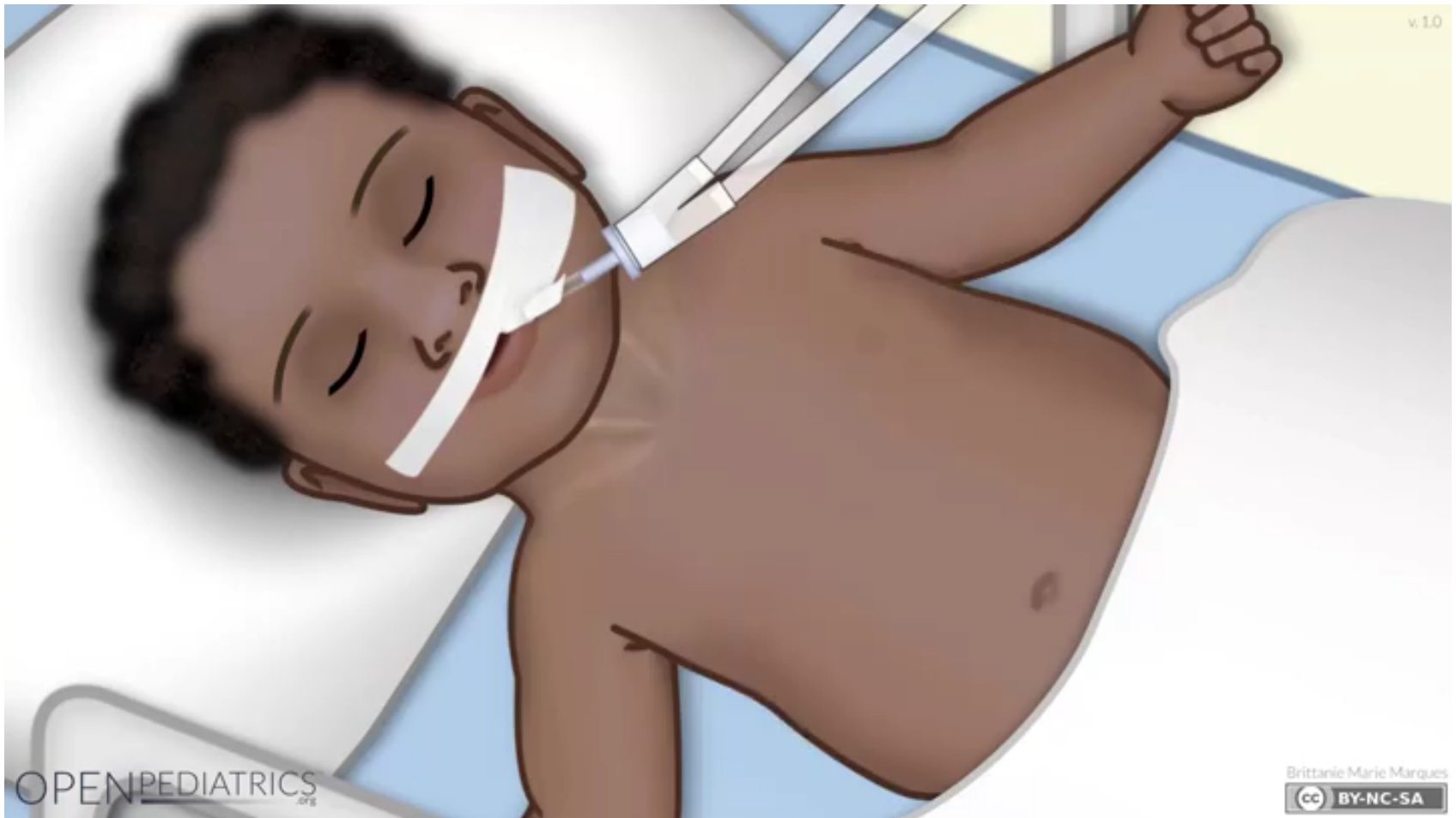
VT 2 ml/kg bzw. < Totraum

CO₂ Clearance = f*VT₂

AF 3- 15 HZ (1 HZ = 60/min)



Wiggle





SM 3100 A



Fabian Accutronic



Twinstream



Leonie plus



Infant star 950



Dräger VN 500



Bunell life pulse



Humming V

Oscillaton

HFOV

HFJV

HFFI

Kolben – piston	Non – piston	Jet	
SM 3100 A S3100B Sensor Medics®	Babylog 8000+	Bunnell Life Pulse	Infant Star 950
	Dräger VN500	Monsoon	Bronchotron
Leoni plus H u. L®	SLE 5000	Paravent	VDR Sandpoint®
Humming V, Vison Alpha Metran®	<u>Fabian</u> Acutronic®	Chirajet	
Flowline Dragonfly		<u>Twinstream</u>	
Stephanie SHF 3000			

Literatur Dilemma



2013

- OSCAR



- OSCILATE

ORIGINAL ARTICLE

High-Frequency Oscillation in Early Acute Respiratory Distress Syndrome

Niall D. Ferguson, M.D., Deborah J. Cook, M.D., Gordon H. Guyatt, M.D., Sangeeta Mehta, M.D., Lori Hand, R.R.T., Peggy Austin, C.C.R.A., Qi Zhou, Ph.D., Andrea Matte, R.R.T., Stephen D. Walter, Ph.D., Francois Lamontagne, M.D., John T. Granton, M.D., Yaseen M. Arabi, M.D., et al., for the OSCILLATE Trial Investigators and the Canadian Critical Care Trials Group*

Non superiority ?

- Inadequate Patientenselektion
- Suboptimale Protokolle für HFOV Einstellungen



Kinderstudien RCT

[illegible]

REVIEW

High-frequency oscillatory ventilation in children: A systematic review and meta-analysis

Fernanda M. D. Junqueira MD¹ | José A. H. Nadal MD, MSc¹ |
Marcelo B. Brandão MD, PhD¹ | Roberto J. N. Nogueira MD, PhD^{1,2} |
Tiago H. de Souza MD, PhD¹ Päd. Pulmonology 2021

28 Tage bis 18 Jahre

11 Studien

2605 Patienten

The scarce evidence currently available does not allow us to conclude that HFOV has advantages over CMV and further studies are needed to clarify its role in the Treatment of hypoxic respiratory failure in children



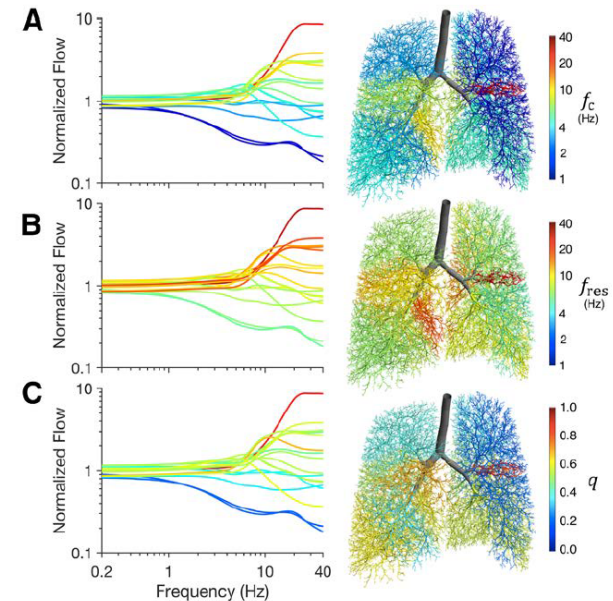
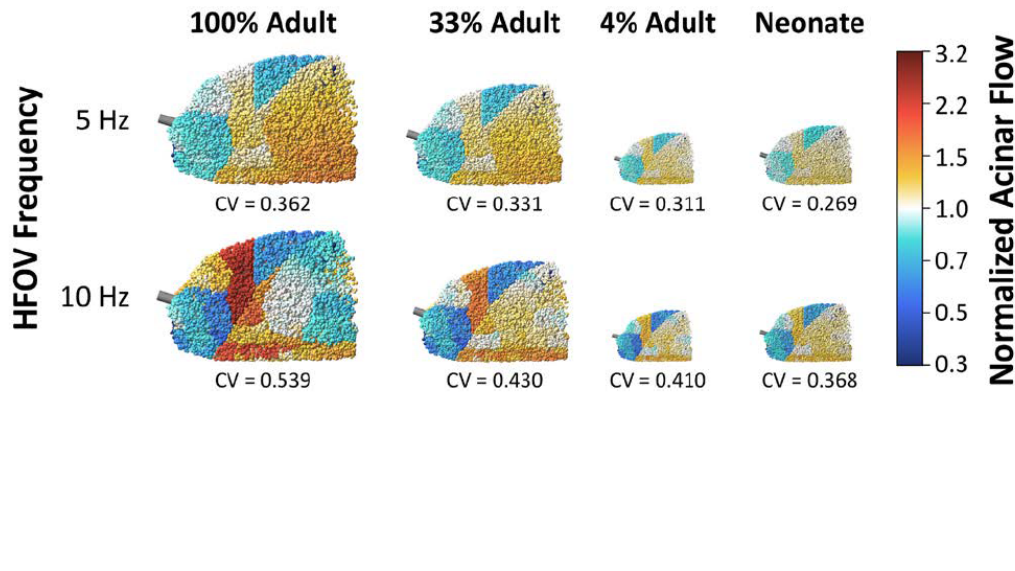
RCT- Bauch/Rückenlage, CMV/HFOV
60 PICUS mit je min. 5 Jahren Erfahrung HFOV und Bauchlage
Two-by-two factorial
Interaction effect of prone positioning with HFOV

Endpunkte:
Ventilator free Days
90 Day in hospital mortality
PICU/Hospital length
Funktionale outcome
HRQL

High-Frequency Oscillatory Ventilation and Ventilator-Induced Lung Injury: Size Does Matter

Jacob Herrmann, PhD^{1,2}; Weerapong Lilitwat, MD³; Merryn H. Tawhai, PhD⁴;
David W. Kaczka, MD, PhD^{1,2,5}

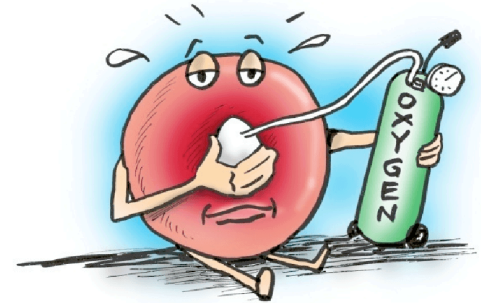
Critical Care 2019



Increasing heterogeneity of parenchymal distension with increasing lung size
Decreasing ratio of deadspace to total acinar volume
With increasing oscillation frequency above lung corner frequency or resonant frequency

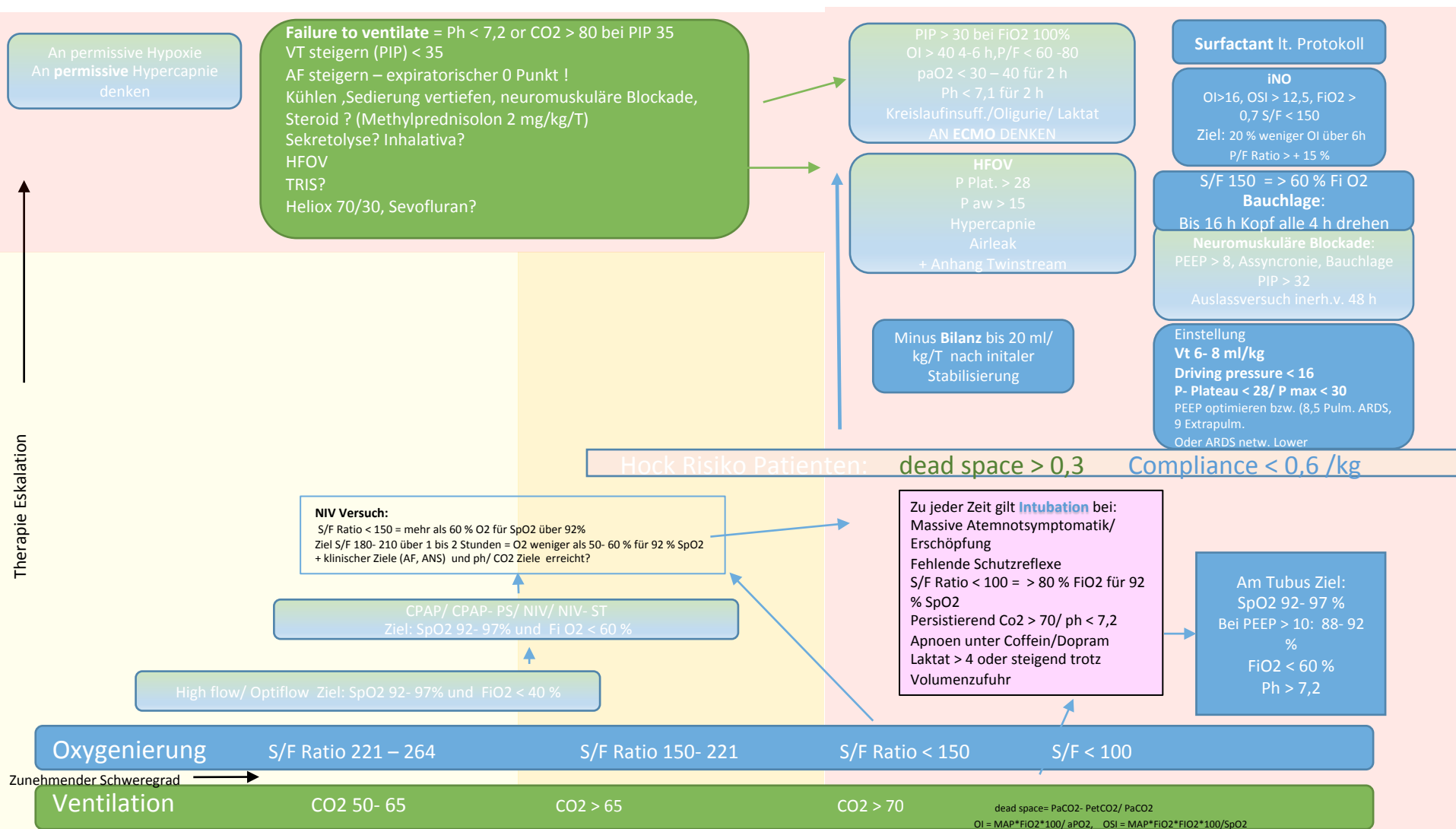
Fazit Literatur

- Oxygenierung wird verbessert

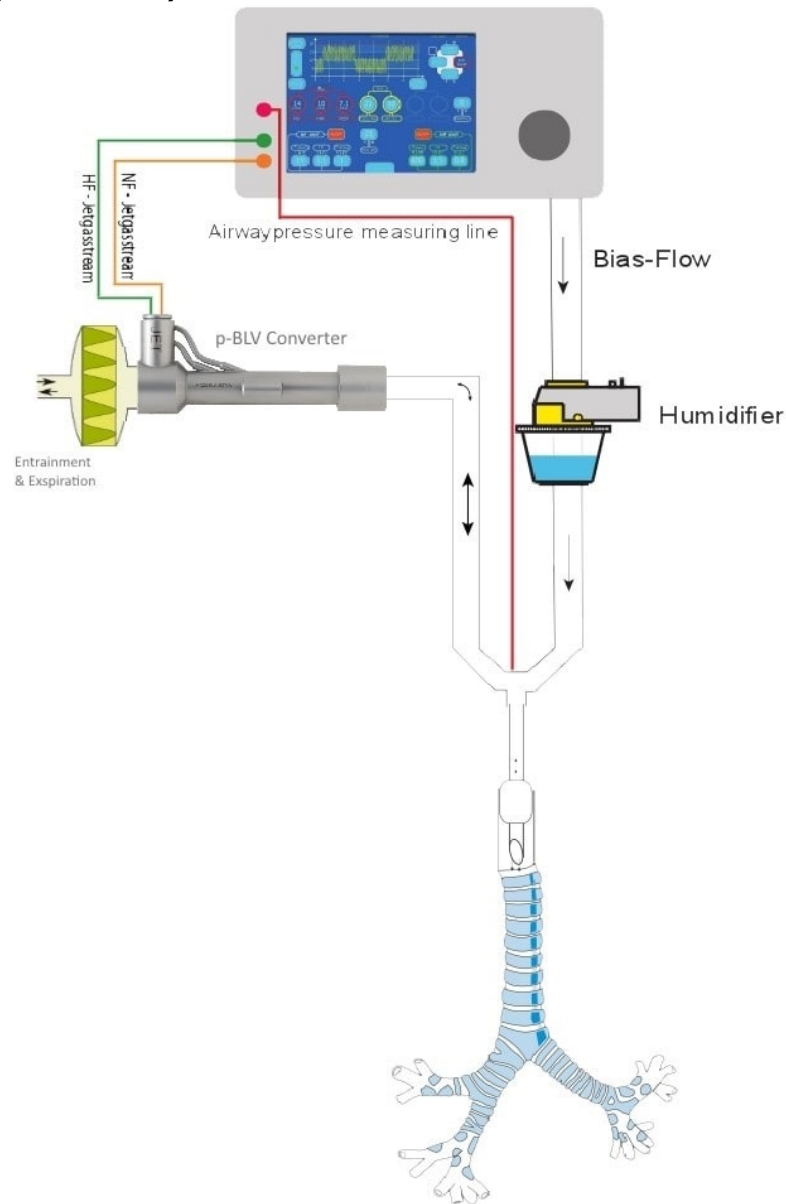


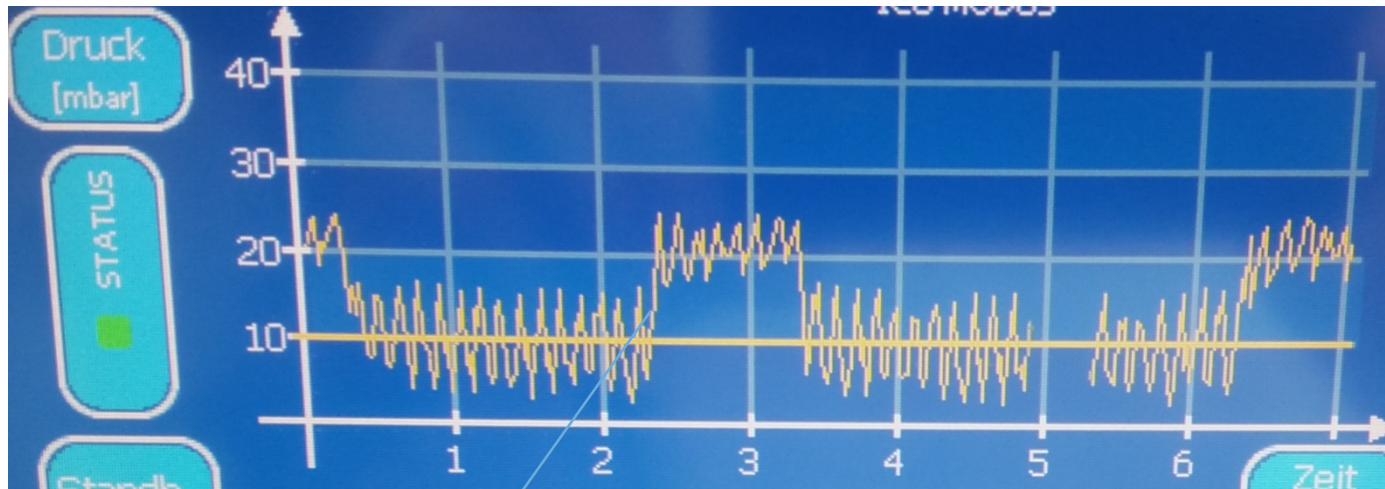
- PARDS Mortalität über Jahre rückläufig
- Anwender/PICU Team mehr Einfluss als Respirator/Beatmungsmodus





Superponierte Bi- Level High Frequency Jet Oscillatory Ventilation (p-BLV)





Oszelationen auf 2 Druckniveaus

Spitzendruck kann abgelesen werden an der Graphik
Keine VT angabe für Konventionelle NF Beatmungsteil
Biasflow für HF Beatmungsteil

Ziele

Blutgase bzw. etCO₂ extern über S1

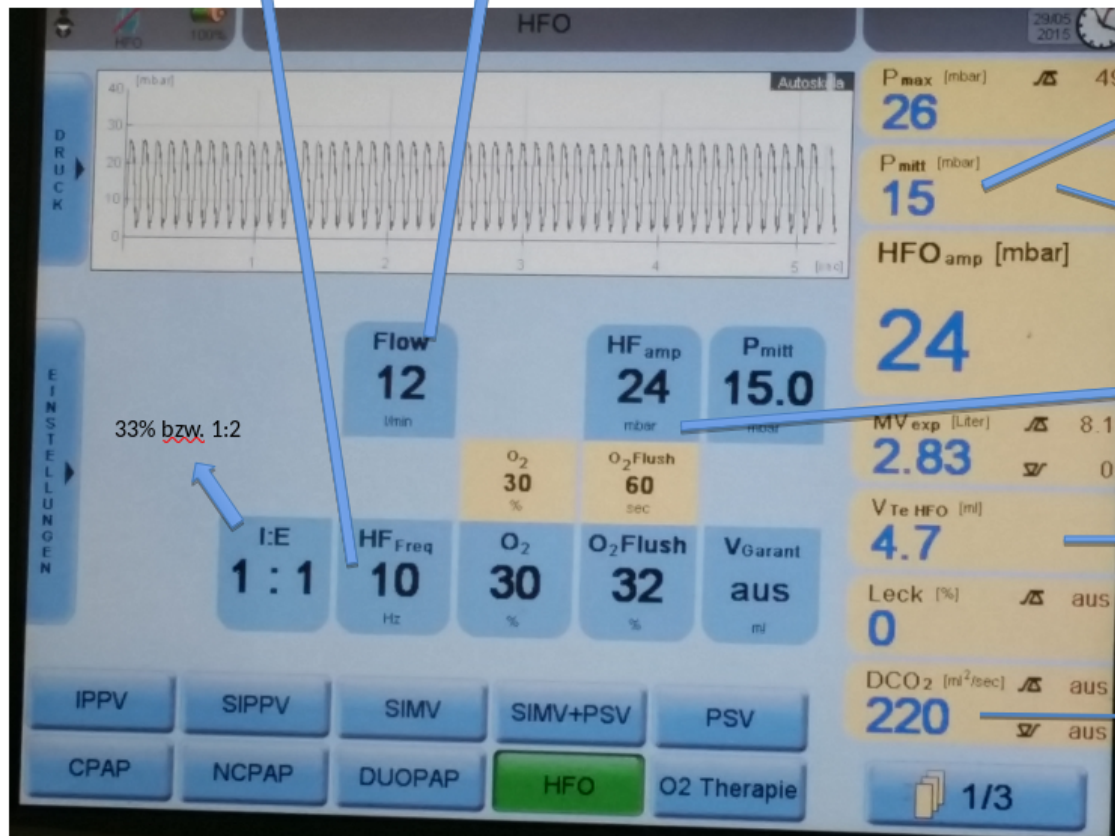
Sichtare/fühlbare Oszelation- Abhören wie konventionelle (NF) möglich

“Konventionelle” HFOV Fabian

8 Neugeborene Kinder/Jug 6- nicht unter 6 (350 am Twinstream)

10 Frühgeborene

Bias Flow 15- 20 l/min. bzw. > 2ml/kg bzw. genung für MAP



2-3 mbar über
MAP - konv, , ggf
Steigern bis 25 mbar
(cave RR Abfall, ZVD Anstieg
Für Recrut. Kurz bis 40 möglich

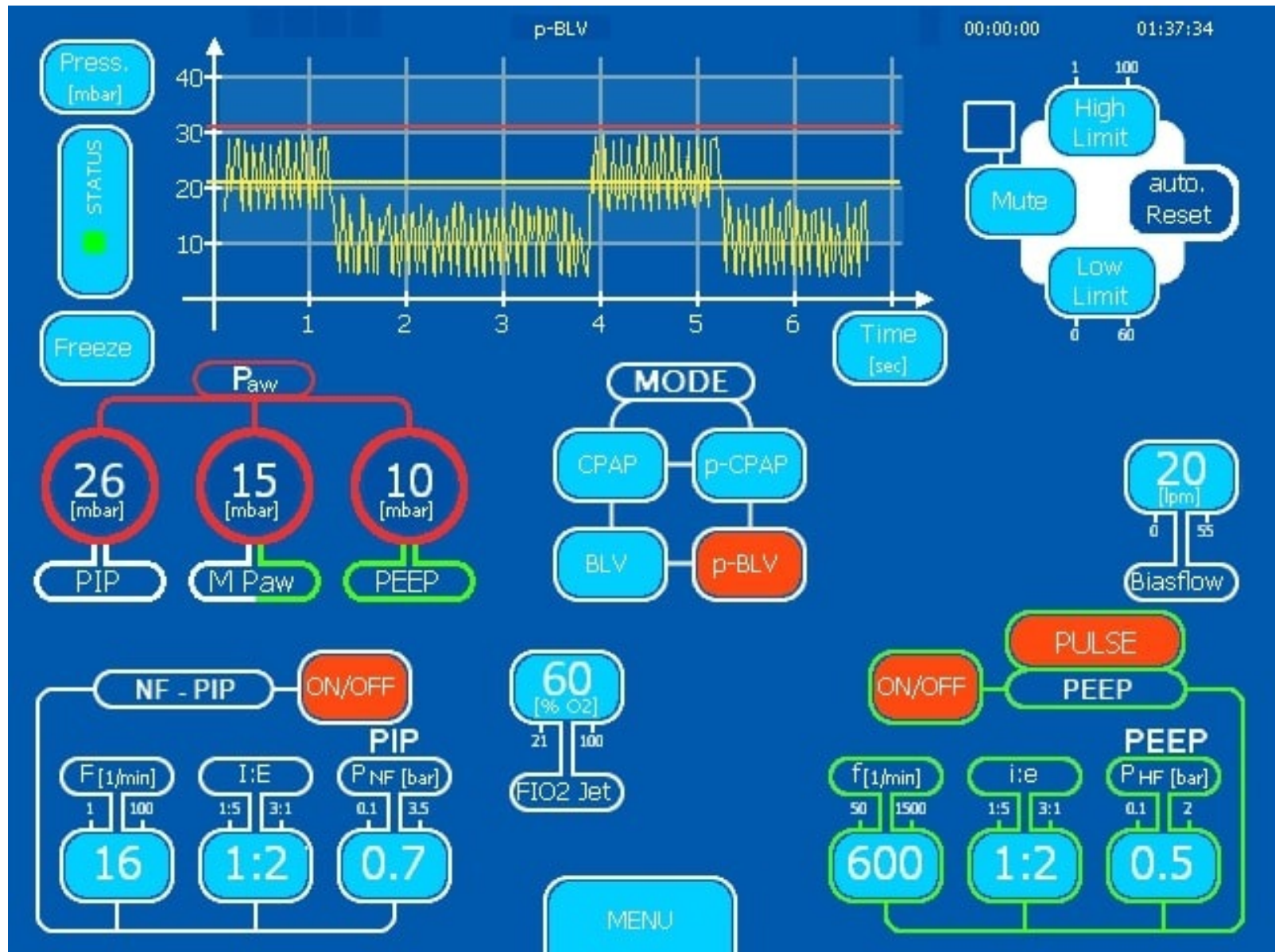
Niedrig Volumen (bei Airleak)
1-2 mbar niedriger als konv.

10-30 FG eher 10 Kinder 30
Neugeb 20
Faustregel: 2x MAP konv.
Baby 40 max
Kind 45 max
Jug 50 max

2 /kg = weniger als
Totram (2,5ml/kg)

Gastransport- Koeffizient
Indirekt proportional PaCO₂
Höherer DCO₂ =
niedrigeres PaCO₂

Interface Twinstream



Indikationen für den Einsatz der pulsatilen BIPhasischen Beatmung (Twinsteam)

Hypoxemie

$SpO_2/FiO_2 < 150$
 $OSI > 10$

Hypercapnie

$Pet\ CO_2 > 50\ mmHg$
 $Pa-etCO_2 > 10$

Beatmungsparameter

$PIP > 28\ mmbar$
 $Paw > 15\ mmbar$
 $FiO_2 > 60$

Für mehr als 3 Stunden

Baro- Volutrauma

Interstitielles Lungenemphysem
Pneumothorax
Pneumomediastinum

Sekretproblem

Exzessive Inhalativa- Therapie
Surfactant Verabreichung

$OSI = \text{Oxygen- Saturation- Index} = (Paw \times FiO_2 \times 100) / SpO_2$

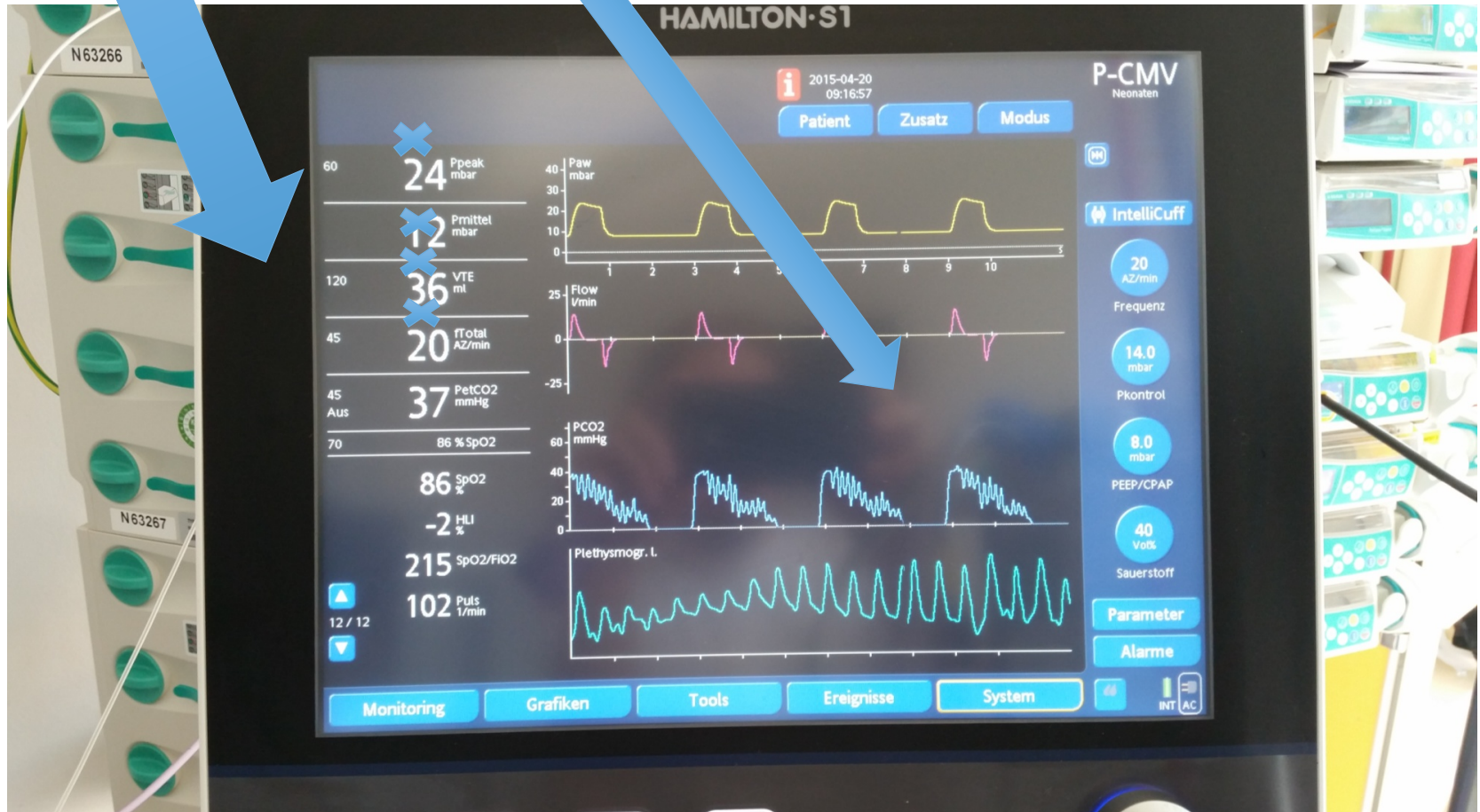
$VI = \text{Ventilations- Index} = (PaCO_2 \times PIP \times AF) / 1000$

Setup



Et Co2, Cuffdruck, Aeroneb,, Pulswelle, spO2/fiO2 und Trends über S1 (beatmet in Beutel)

etCo2 nur Wert verwertbar = erster Teil der CO2 Kurve



Seven Patient (ages 6 months to 15 years) with acute hypoxic respiratory insufficiency (postoperative, 3; viral or bacterial infection, 4) failing conventional mechanical ventilation

**Oxygen saturation, CO2 and ventilatory parameters
befor and after p-BLV (mean, range)**

	Pre- pBLV	Post- pBLV	
SpO2/FiO2, %	114 (73- 160)	262 (217- 320)	p<0,001
OSI	12,8 (7,8- 27,4)	4,1 (2,7- 4,2)	p<0,001
Paw, mbar	12,6 (10- 20)	10,2 (8,8- 12)	p<0,01
VI	34,4 (10,3- 45)	25,9 (12- 34)	p<0,001
Pa-etCO2, mmHg	6,4 (0,5- 15)	1,4 (0,9- 8)	p<0,01

OSI: oxygen saturation index
($Paw \cdot FiO_2 \cdot 100 / SpO_2$)
VI: ventilatory index
($PIP \cdot PaCO_2 \cdot RR / 100$)
Paw: mean airway pressure
RR: respiratory rate

Manual of Neonatal Respiratory Care

Steven M. Donn
Mark C. Mammel
Anton H. L. C. van Kaam
Editors

Fifth Edition

The Twinstream Respirator 2022
Raphael Ulreich

