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brain tissue  $PO_2$  ( $P_{br}O_2$ ) monitoring in  
traumatic brain injury: past & future

why do we measure brain tissue  $PO_2$   
( $P_{br}O_2$ ) ?



## SjvO<sub>2</sub>, desaturation episode

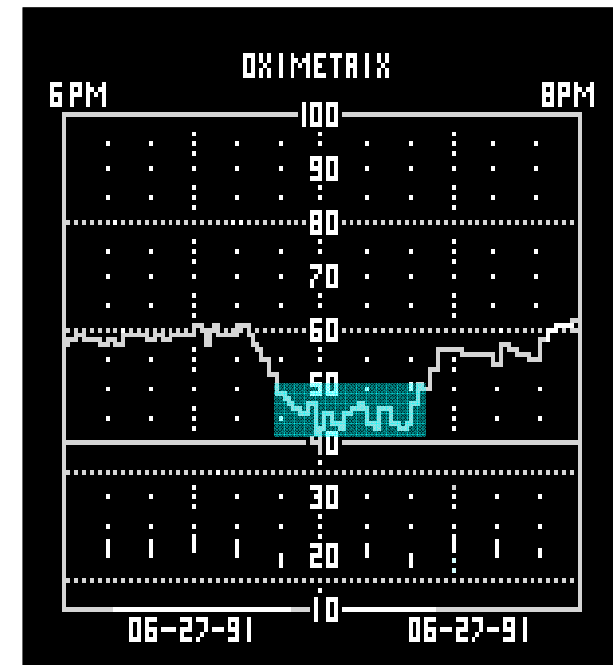
■ Def.: SjvO<sub>2</sub> < 50%, t > 10 min

■ increased morbidity & mortality

multiple DE: 90% „unfavourable outcome“

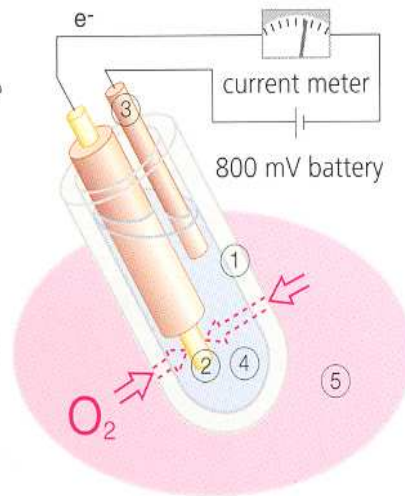
single DE: 74% „unfavourable outcome“

no DE: 55% „unfavourable outcome“



# PbrO<sub>2</sub>, Clark-type electrode

- 1 Polyethylene tube diffusion membrane
- 2 Polarographic Gold cathode
- 3 Polarographic Silver anode
- 4 Electrolyte filled cell
- 5 Tissue

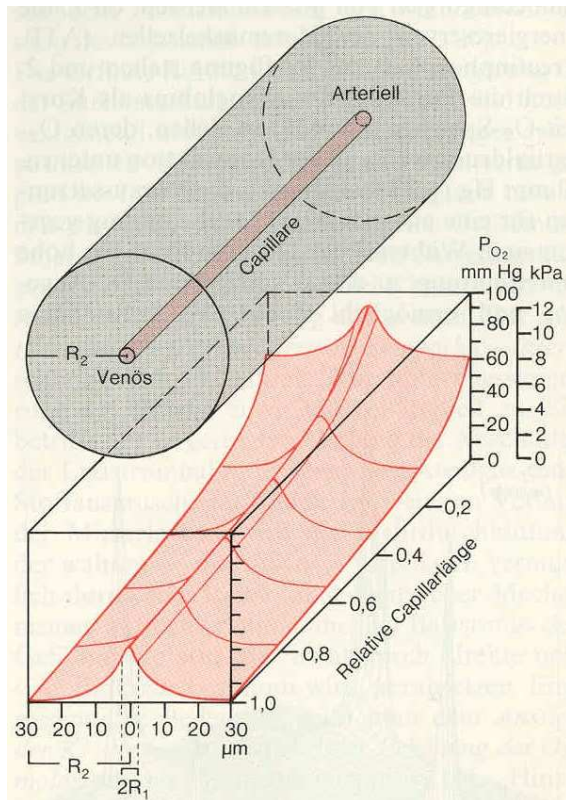




# PO<sub>2</sub> in the Krogh cylinder



August Krogh (1874 – 1949)  
Nobel Prize 1920



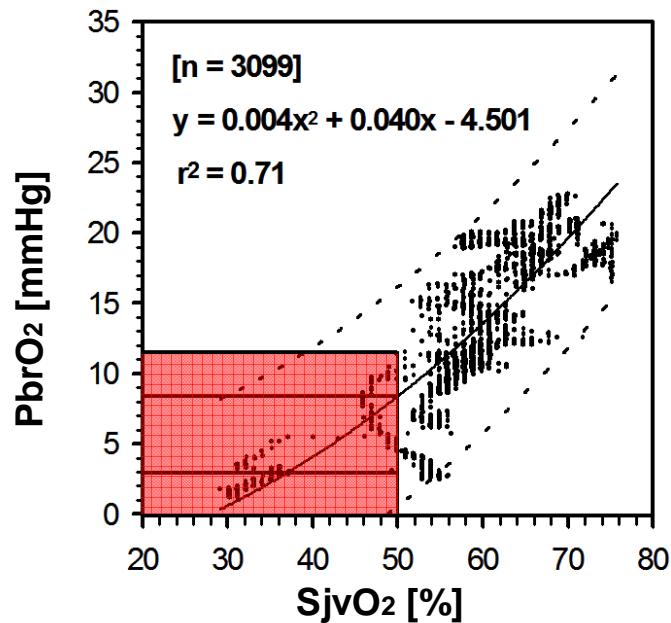
- PO<sub>2</sub>...  
...determines O<sub>2</sub> diffusion distance

- arterial O<sub>2</sub> content...  
...is not determined by PO<sub>2</sub> but  
...Hb and SaO<sub>2</sub>

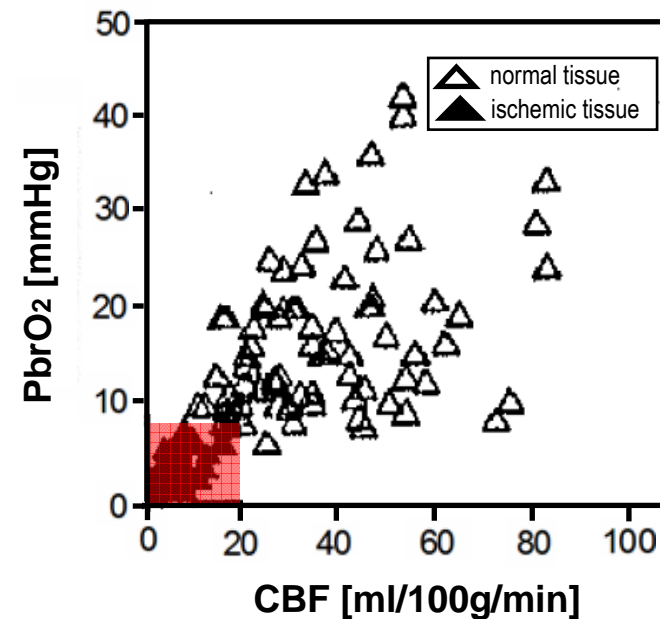
	PaO <sub>2</sub> [mmHg]	PcapO <sub>2</sub> [mmHg]	O <sub>2</sub> diffusion distance [ $\mu\text{m}$ ]
RA (FiO <sub>2</sub> = 0,21)	100	90 - 30	64 - 36
NBHO (FiO <sub>2</sub> = 1)	400	280 - 120	90 - 66
HBHO (3 bar)	2000	1400 - 600	247 - 135



# critical threshold of PbrO<sub>2</sub> – S<sub>iv</sub>O<sub>2</sub> & CBF



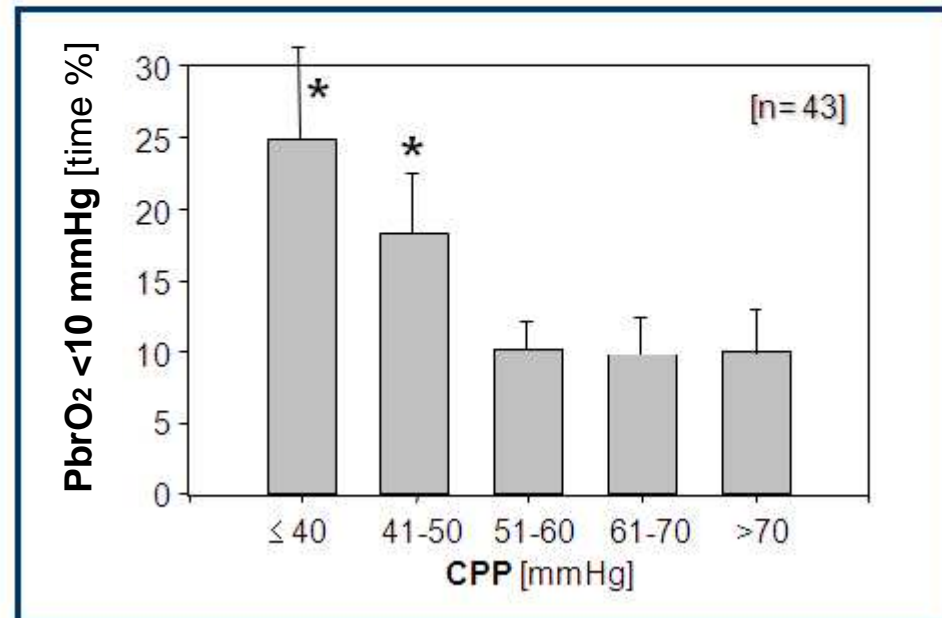
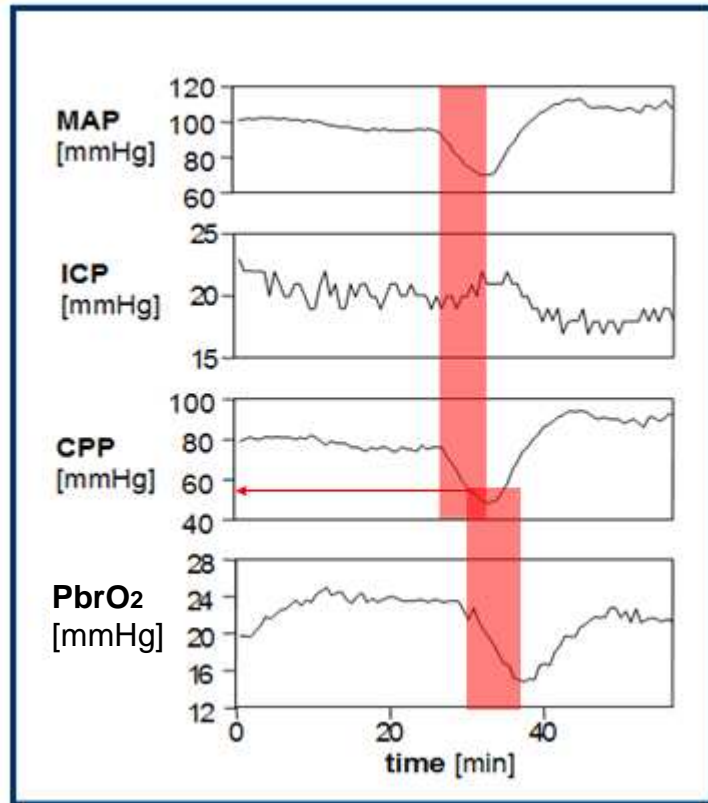
- TBI
- clinical data
- critical P<sub>ti</sub>O<sub>2</sub> = 8.5 mmHg



- ischemia (MCA occlusion)
- experimental data (cats)
- critical P<sub>ti</sub>O<sub>2</sub> = 8 mmHg



# PbrO<sub>2</sub> vs. CPP



Kiening, **J Neurosurg**, 1996

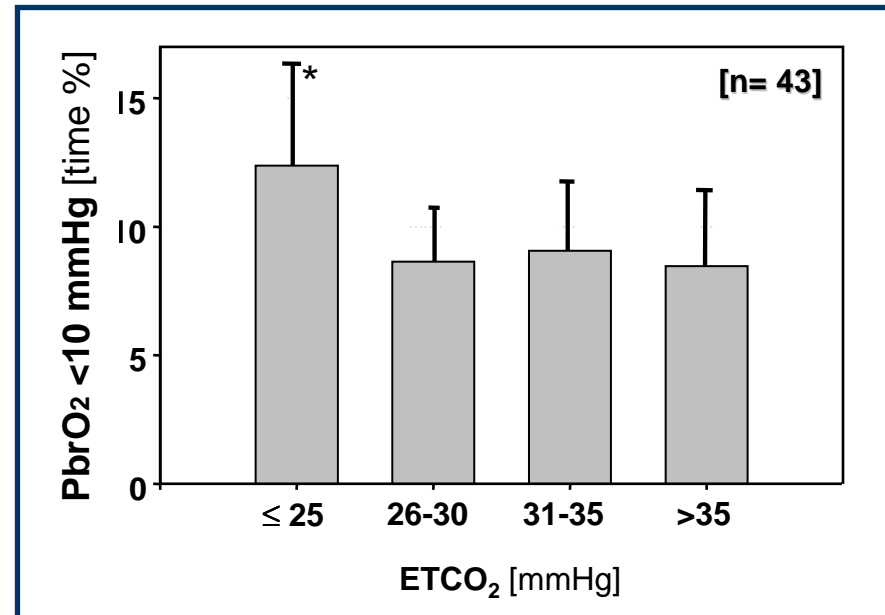
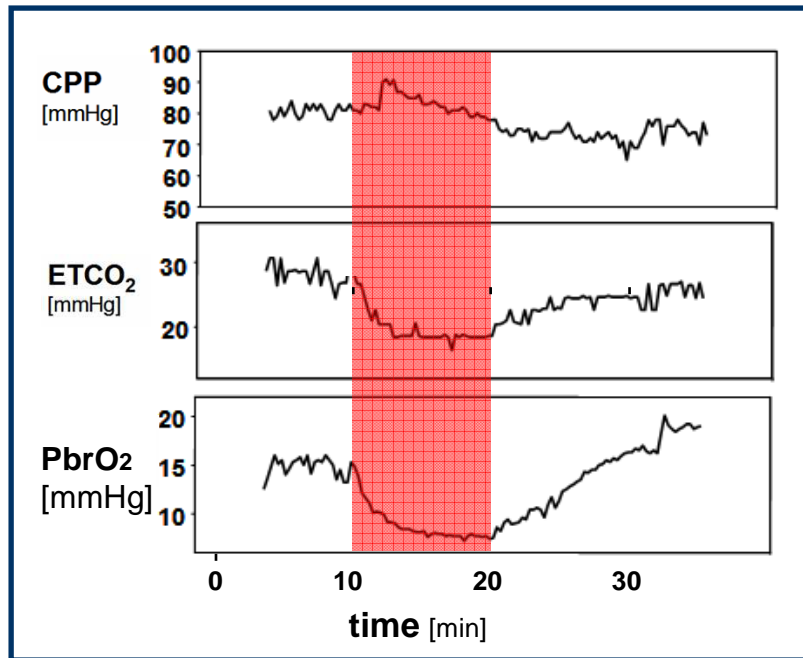
Kiening, **Neurol Res**, 1997

Bardt, **Acta Neurochir**, 1998





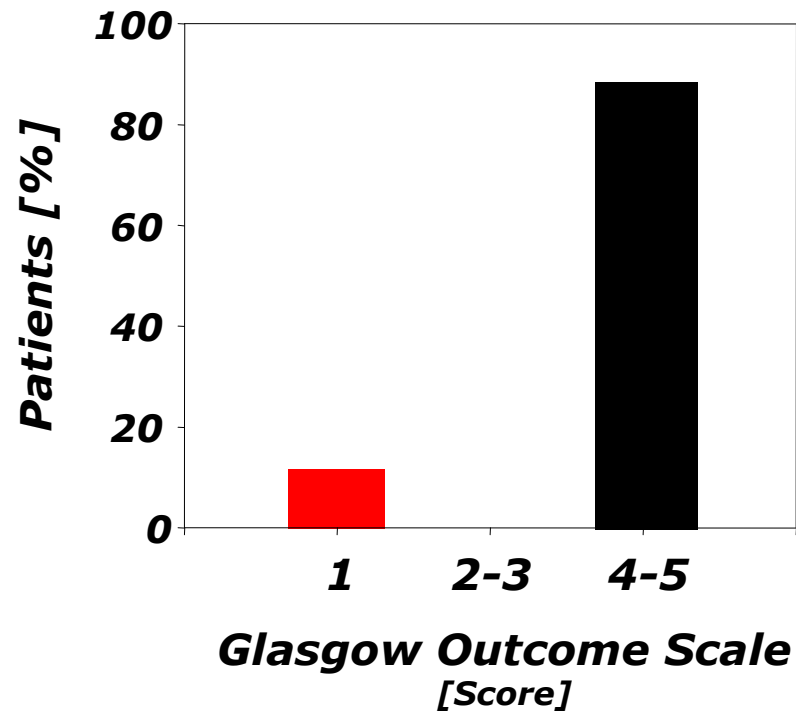
# PbrO<sub>2</sub> vs. PCO<sub>2</sub>



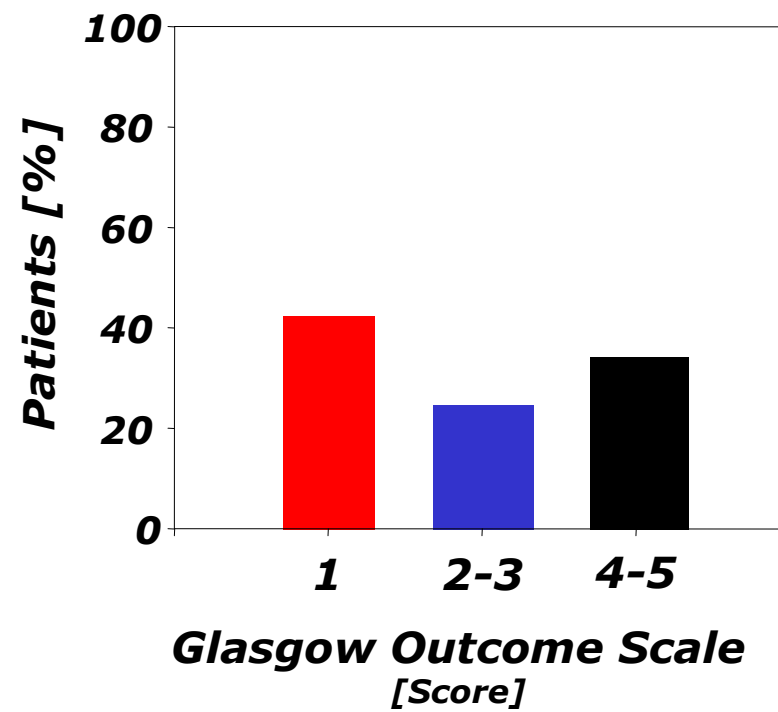


# PbrO<sub>2</sub> impact on outcome

**PbrO<sub>2</sub> < 10 mmHg  
< 30 Min [n=20]**



**PbrO<sub>2</sub> < 10 mmHg  
> 30 Min [n=23]**







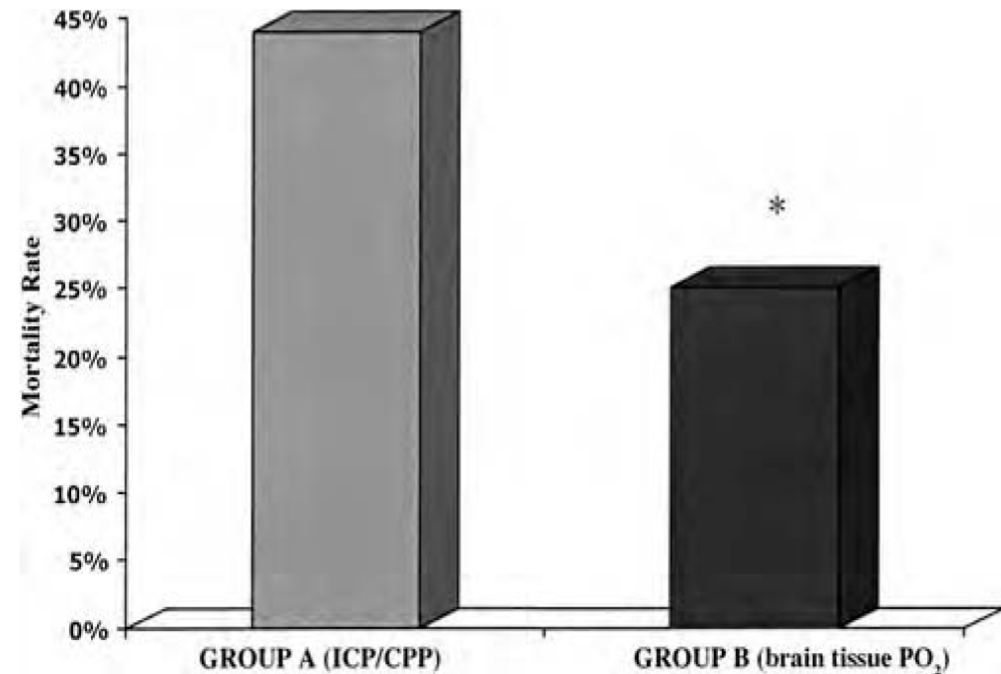
# PbrO<sub>2</sub> based therapy

## group A:

- $n = 25$
- $ICP < 20 \text{ mmHg} / CPP > 60 \text{ mmHg}$
- „Guidelines“

## group B:

- $n = 28$
- +  $PbrO_2 \geq 25 \text{ mmHg}$
- $FiO_2 \uparrow$  / decompressive surgery

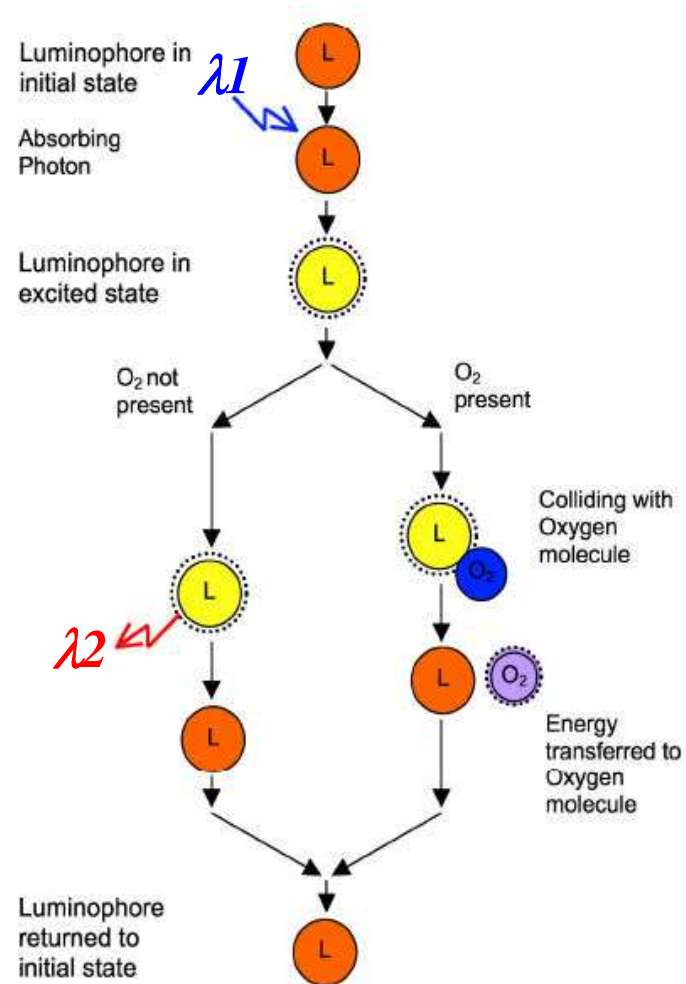




# PbrO<sub>2</sub> measurement by oxygen quenching Neurovent

## LICOX features

storage	fridge
consumes oxygen	yes
consumes electrolytes	yes
long-term monitoring	restricted



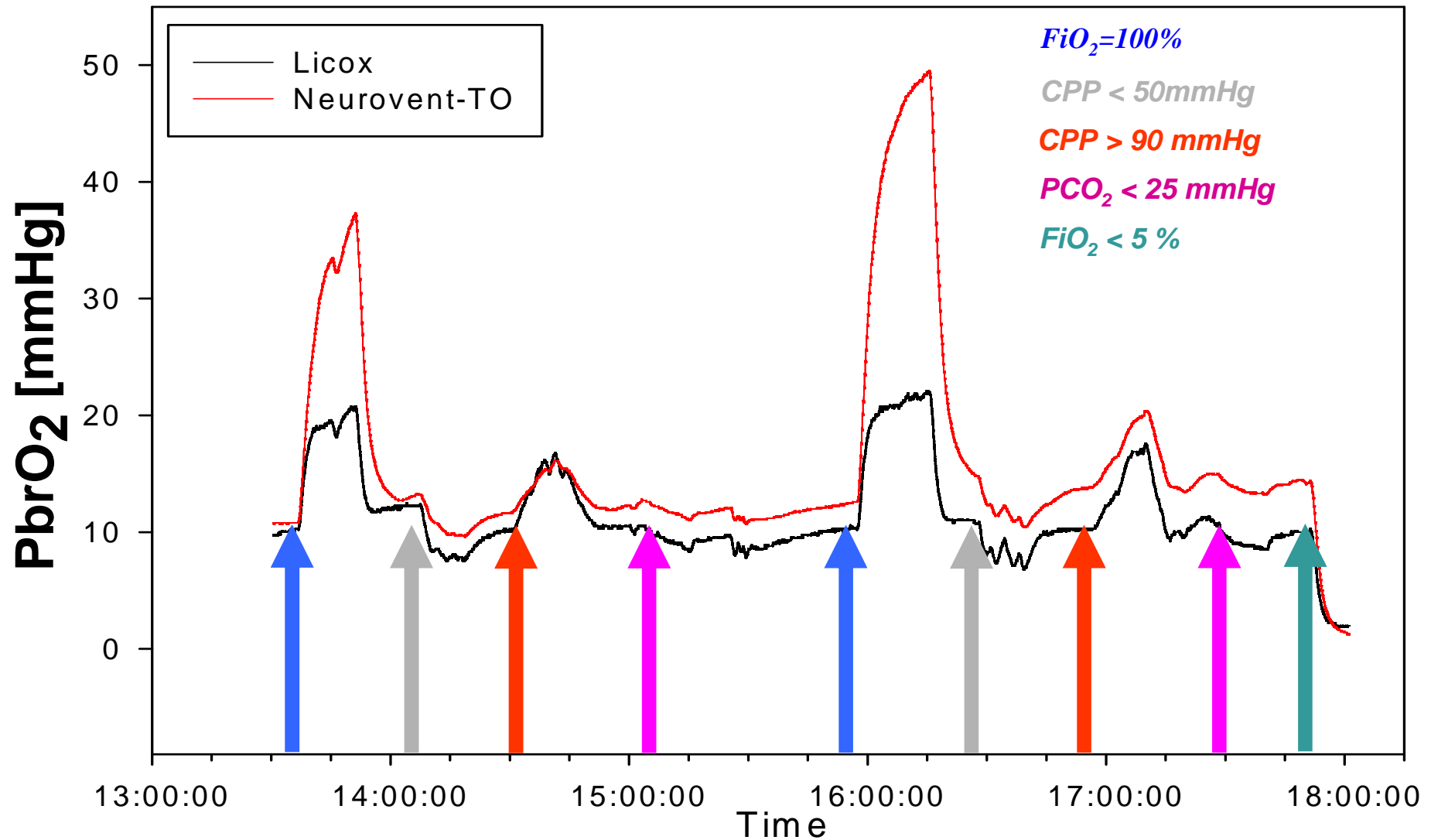


# LICOX vs. Neurovent-TO / -PTO

	<i>LICOX</i>	<i>Neurovent-TO</i>	<i>Neurovent-PTO</i>
<b>storage</b>	fridge	room air	room air
<b>consumes oxygen</b>	yes	no	no
<b>consumes electrolytes</b>	yes	no	no
<b>long-term monitoring</b>	restricted	yes	yes
<b>in-built thermocouple</b>	no	yes	yes
<b>in-built ICP catheter</b>	no	no	yes
<b>diameter</b>	1.5 F / 0,49 mm	3 Fr / 1 mm	5 Fr / 1.65 mm
<b>O<sub>2</sub> uptake area</b>	13 mm <sup>2</sup>	13 mm <sup>2</sup>	22 mm <sup>2</sup>
<b>T<sub>90/35°C</sub></b>	70 s	< 200 s	<200 s

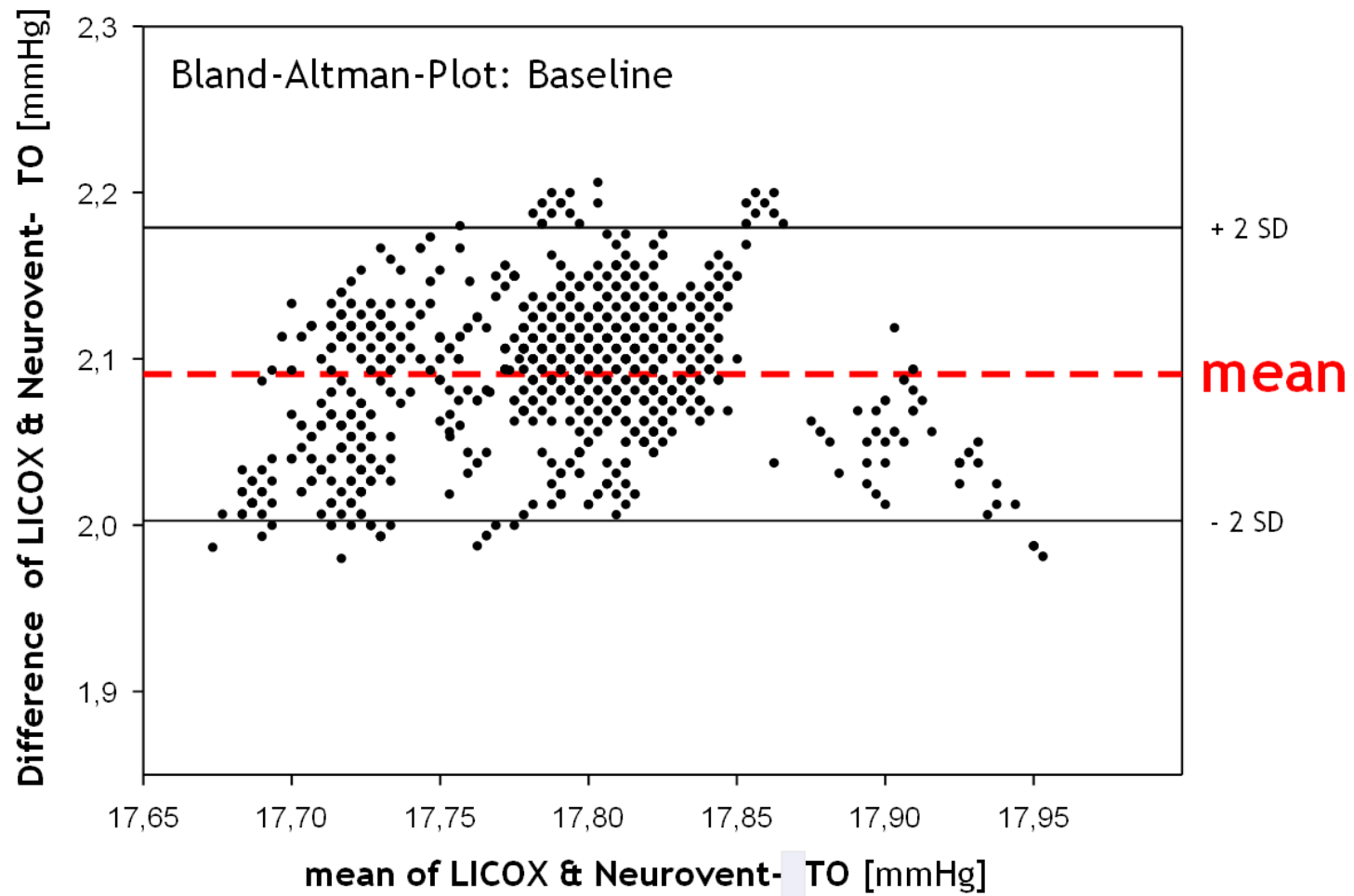


# LICOX vs. Neurovent-TO (swine model; n = 9) - Protocol



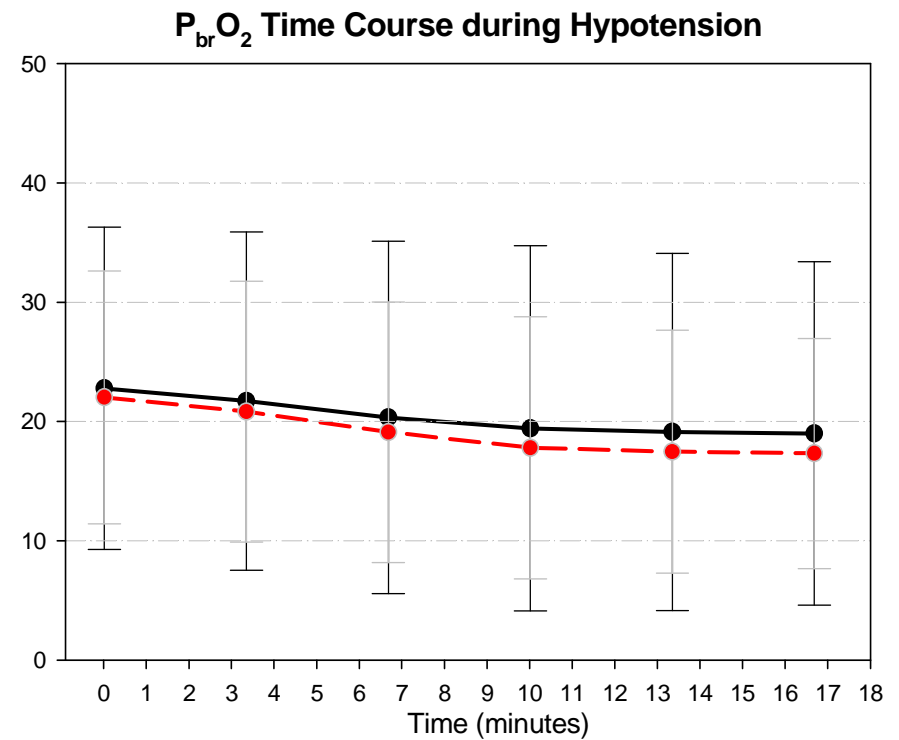
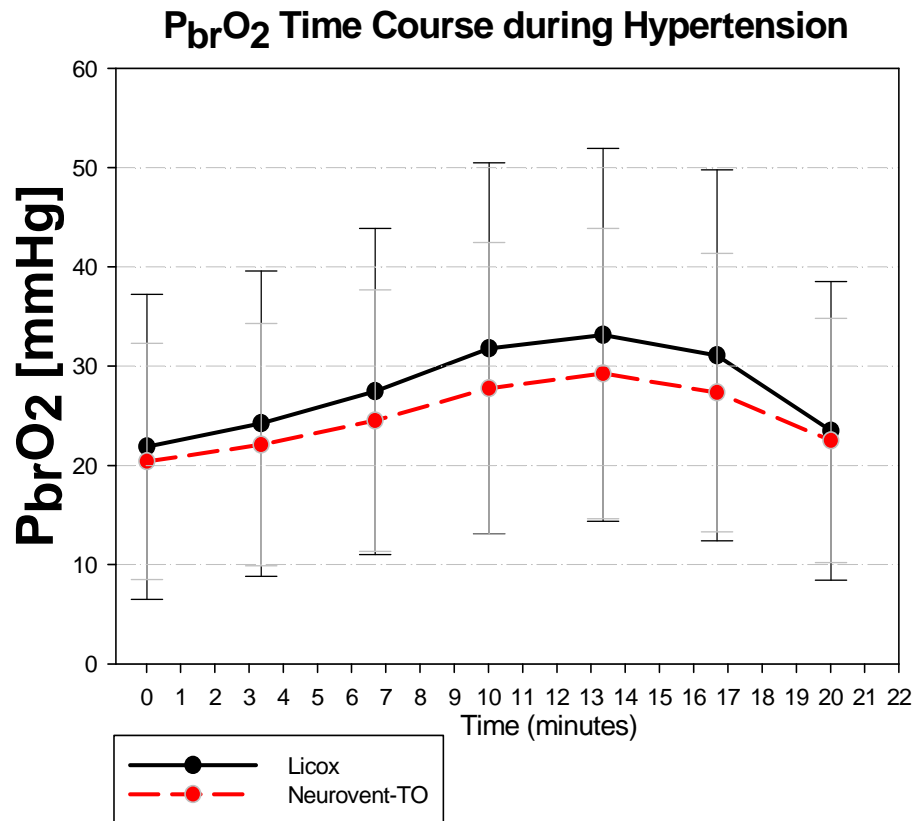


# LICOX vs. Neurovent-TO (swine model; n = 9) – Baseline





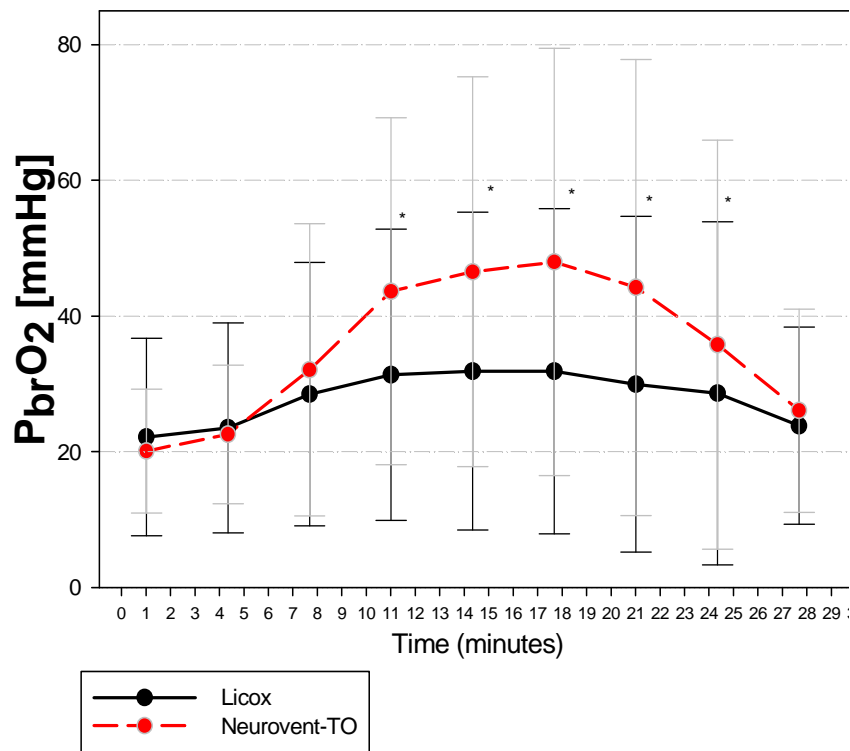
# LICOX vs. Neurovent-TO (swine model; n = 9) – Hyper-/Hypotension



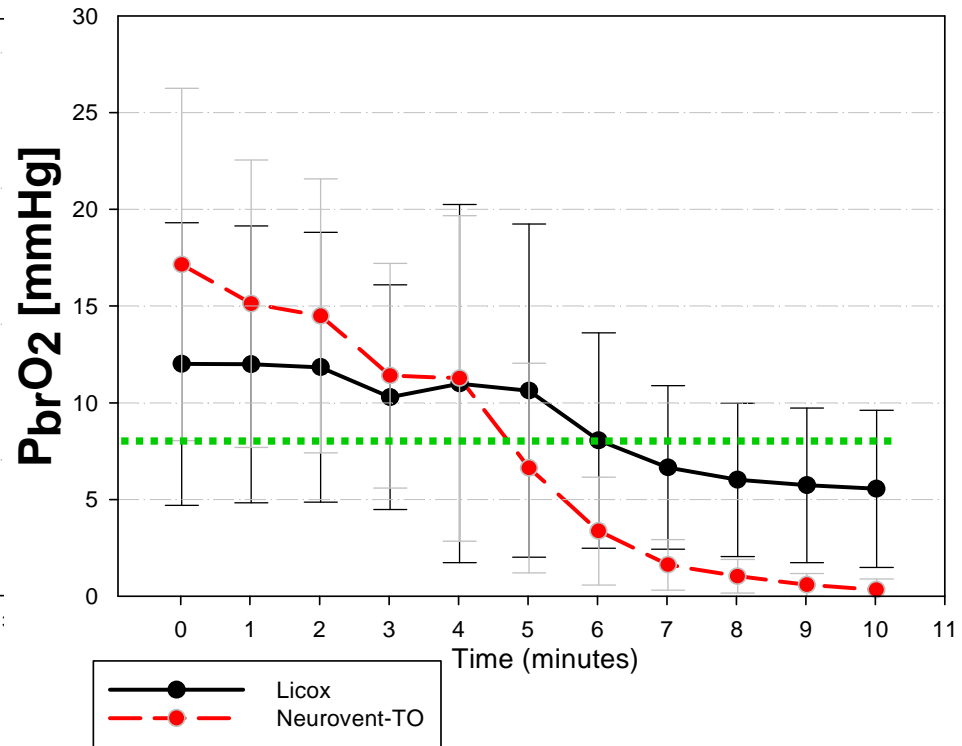


# LICOX vs. Neurovent-TO (swine model; n = 9) – Hyper-/Hypooxygen.

$P_{brO_2}$  Time Course during Hyperoxygenation



$P_{brO_2}$  Time Course during Hypoxia



▪ significant differences in response to hyper-/hypooxygenation  
⇒ probe-specific thresholds for critically low  $P_{brO_2}$ -values needed ?





## PbrO<sub>2</sub>: Summary

»the wish was father to the thought«

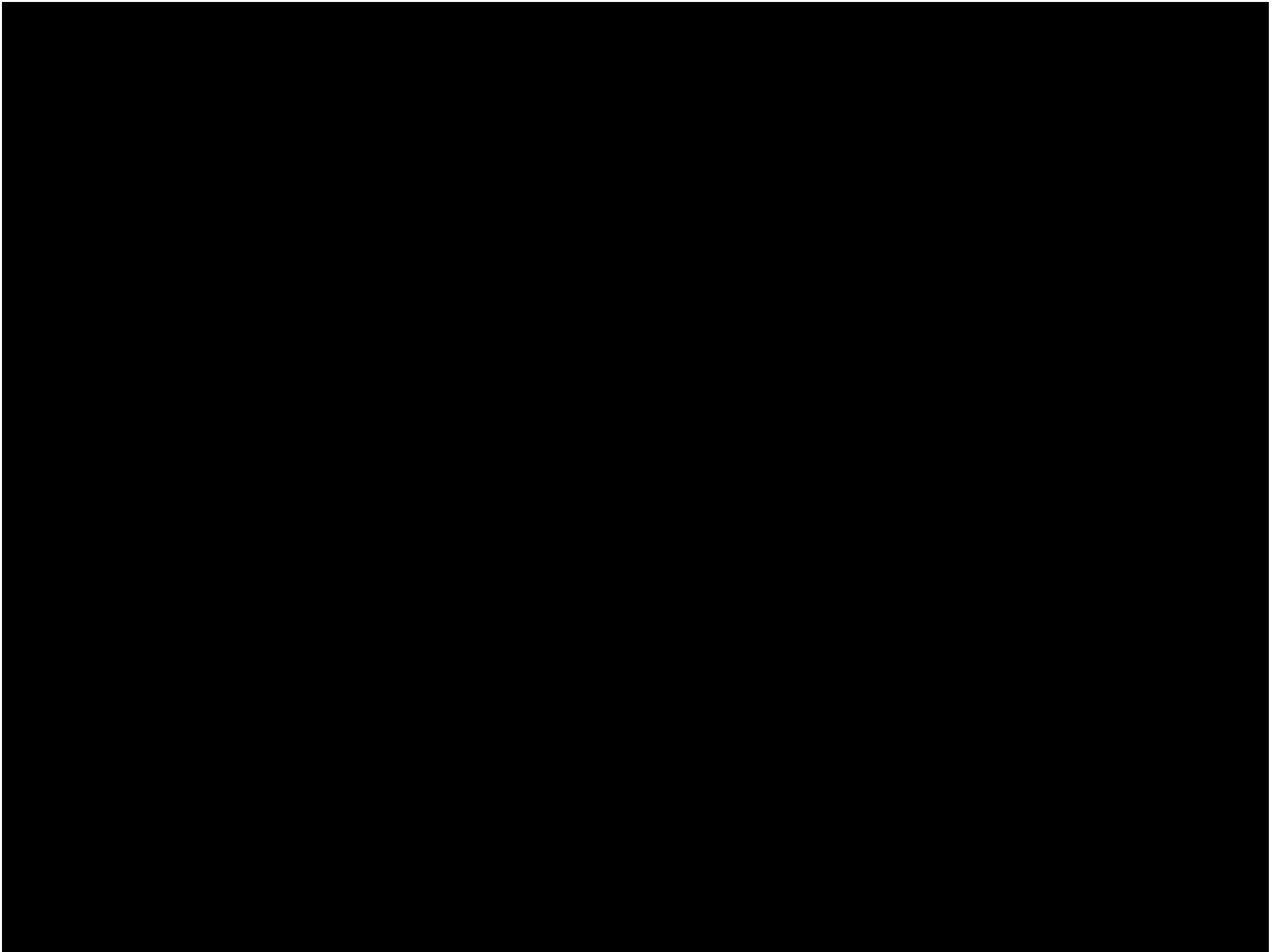
SjvO<sub>2</sub>, Clark-type PbrO<sub>2</sub> electrode

»Rome wasn't built in a day«

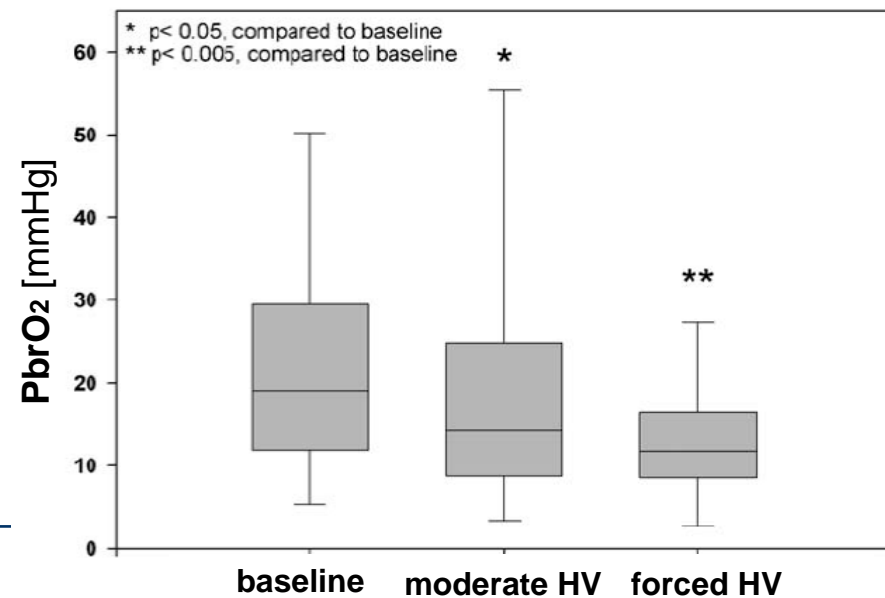
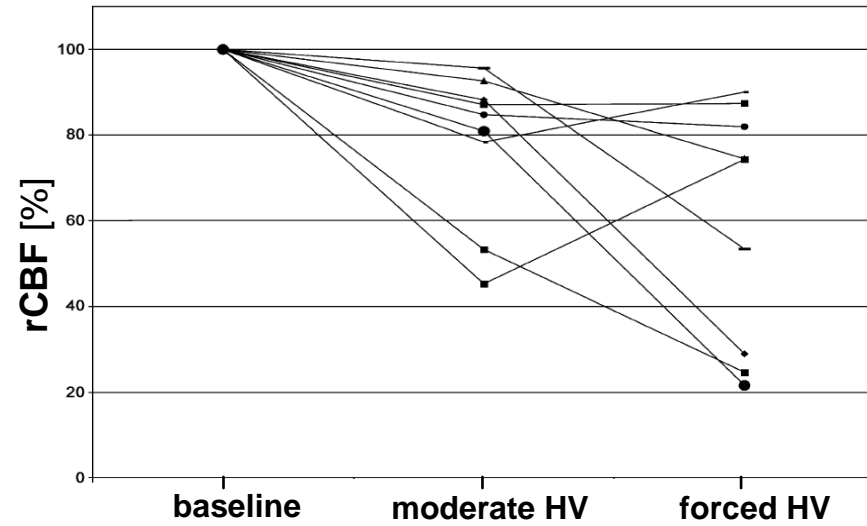
15 years from research to clinical routine

»new broom sweeps clean, but not always the same street«

Neurovent-TO /-PTO



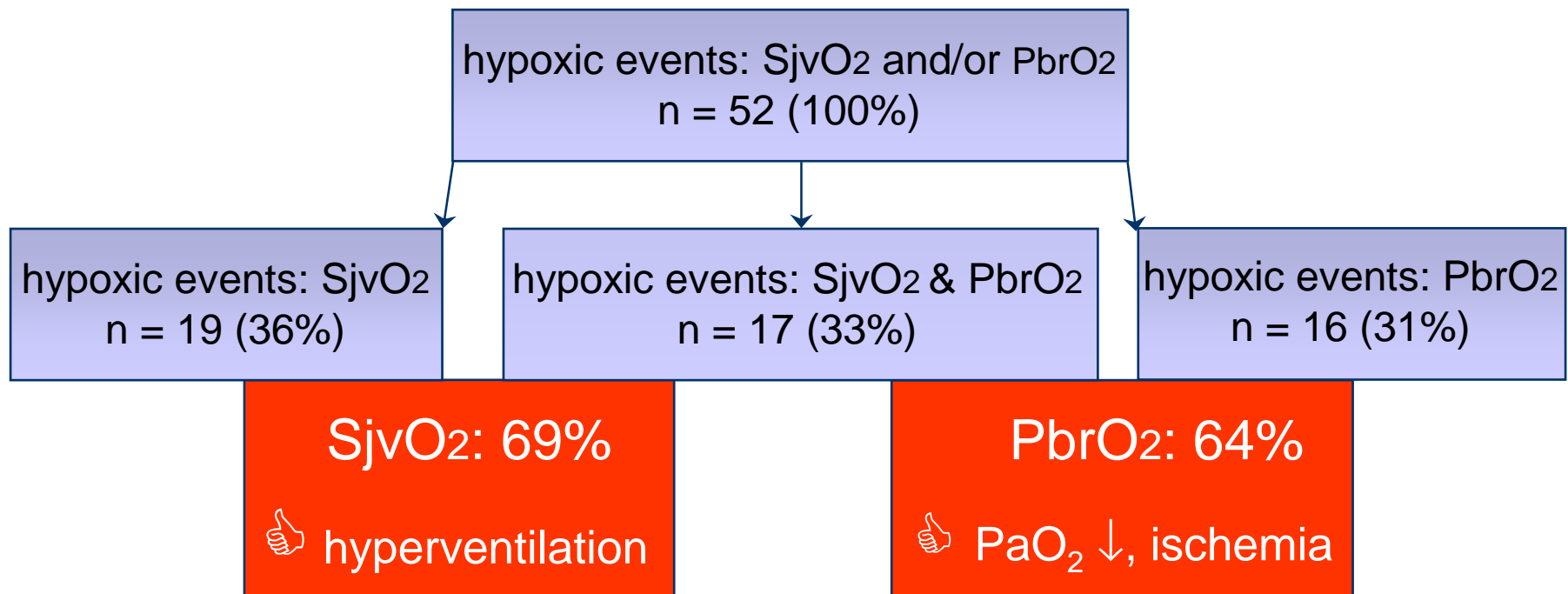
# PbrO<sub>2</sub> vs. PCO<sub>2</sub> – “one size doesn’t fit all”





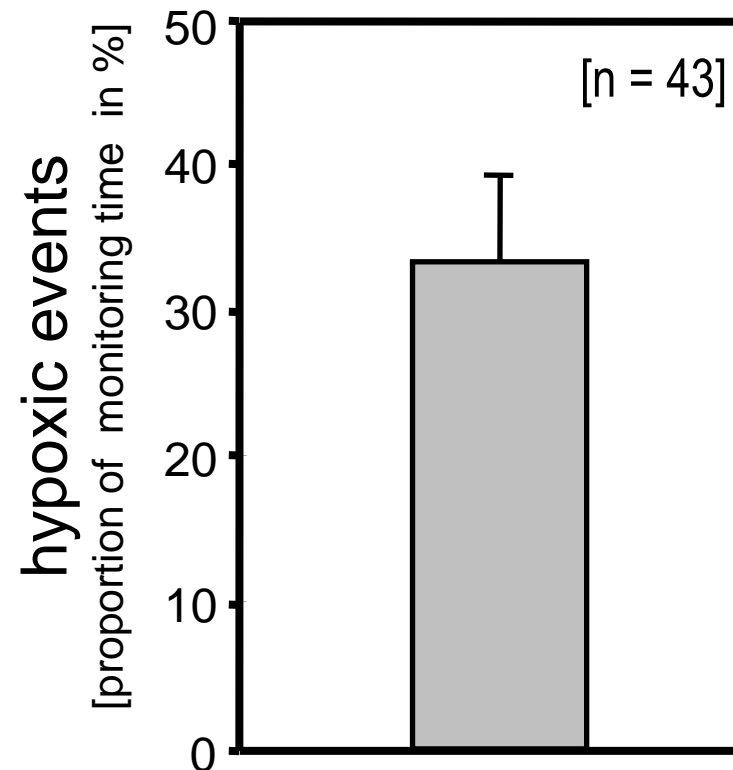
## PbrO<sub>2</sub> vs. SjvO<sub>2</sub> (clinical data, TBD)

- n<sub>pat.</sub>: 58, simultaneous SjvO<sub>2</sub> & PbrO<sub>2</sub> monitoring
- hypoxic thresholds used: SjvO<sub>2</sub>: 50% | PtiO<sub>2</sub>: 8 mmHg





# hypoxic events despite “non-critical” ICP, CPP & PCO<sub>2</sub>





# critical threshold of PbrO<sub>2</sub> – microdialysis (clinical data, TBD)

