

Prone Position - KLRT - Hirndruck

- Der kritisch kranke Patient -



[kit]: Kasseler
Intensivpflegetage

Dr. med. Jens
Kleffmann, LL.M.

**Klinik für
Neurochirurgie**

Zentrum für Kopf-
und Neuromedizin

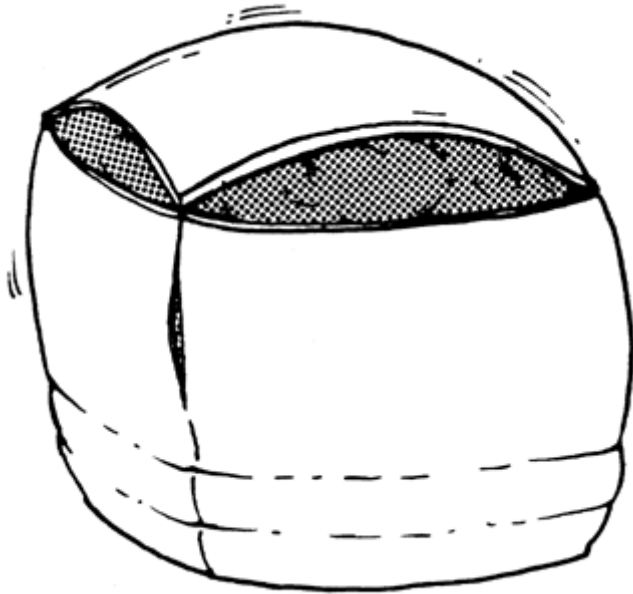
Klinikum Kassel

Direktor
Prof. Dr. med.
W. Deinsberger

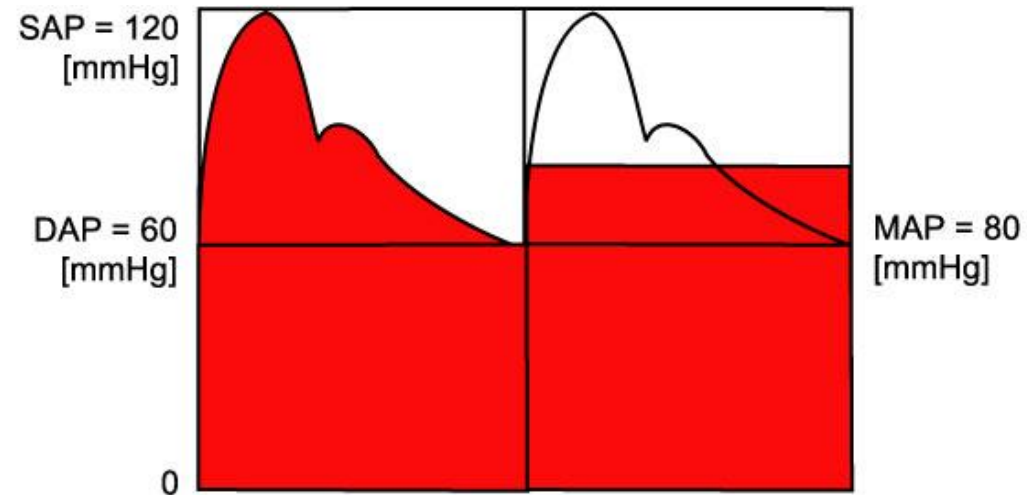
**Gesundheit
Nordhessen**

11. Kasseler Intensivpflegetage – [kit]:
Kassel, 23. April 2015

ICP – Intracranial pressure



ICP



MAP

ICP – Intracranial pressure

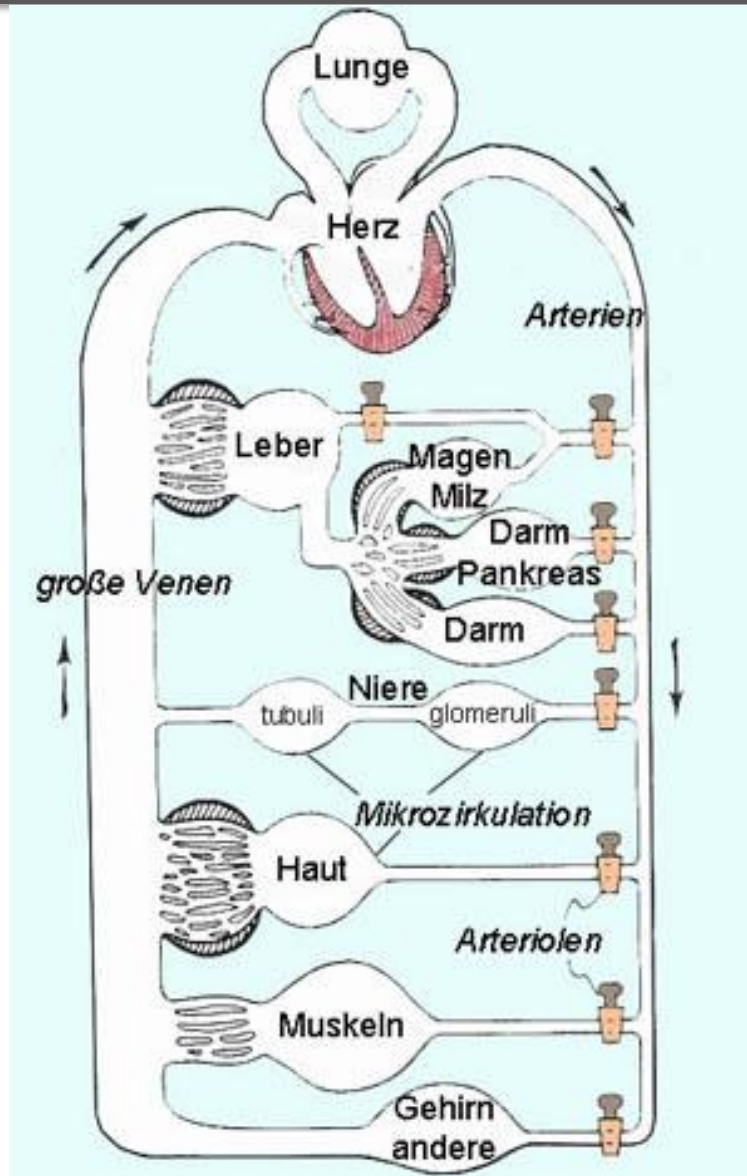
$$\text{CPP} = \text{MAP} - \text{ICP}$$

ICP
< 20mmHg



CPP
> 70 mmHg

ICP – Intracranial pressure



$\approx 50 \text{ ml}/100\text{g}/\text{min}$

graue Substanz $\approx 100 \text{ ml}/100\text{g}/\text{min}$
weiße Substanz $\approx 25 \text{ ml}/100 \text{ g}/\text{min}$

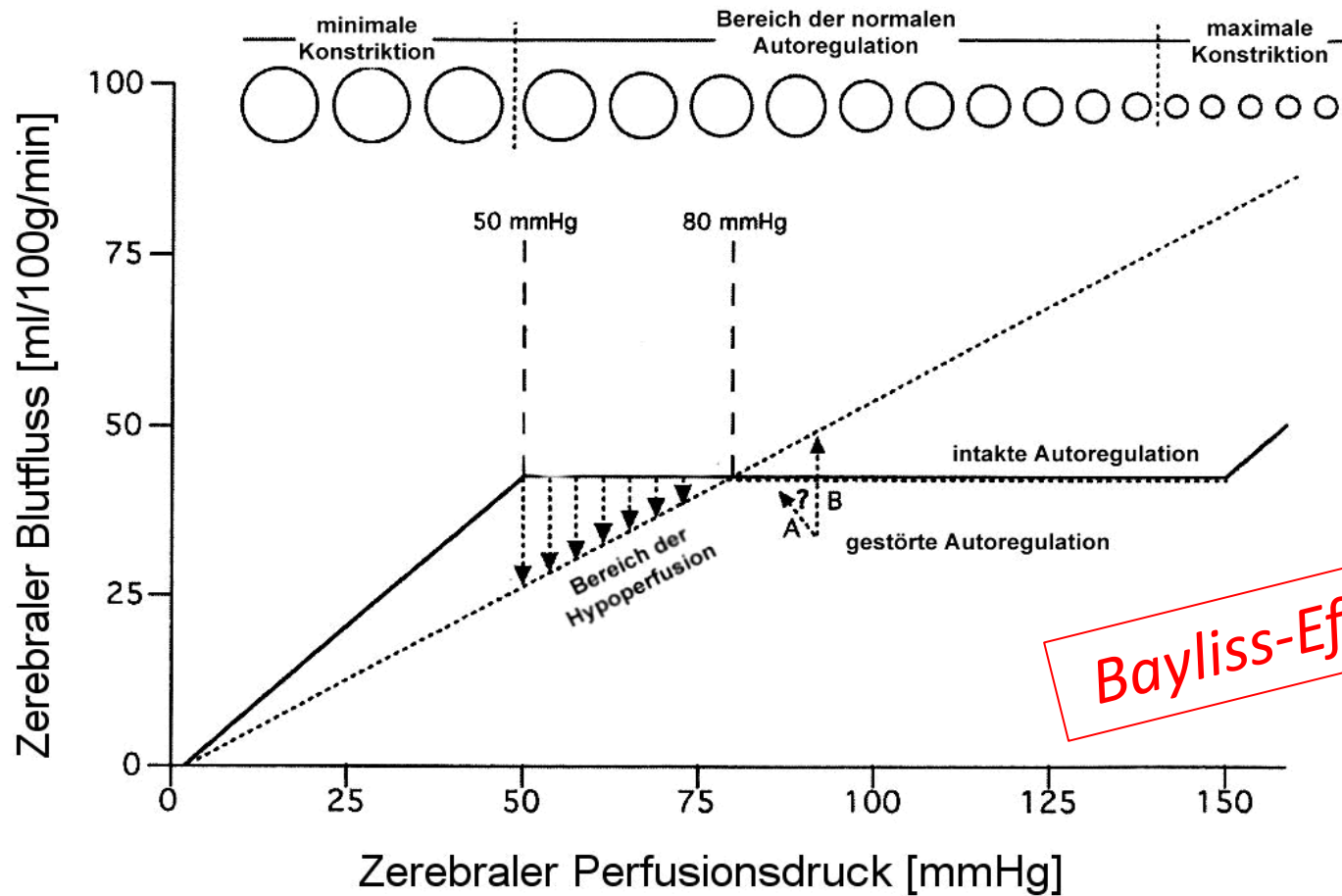
→ 20% des HZV

arterio-venöse
Sauerstoffdifferenz
6-7 ml/100 ml Blut

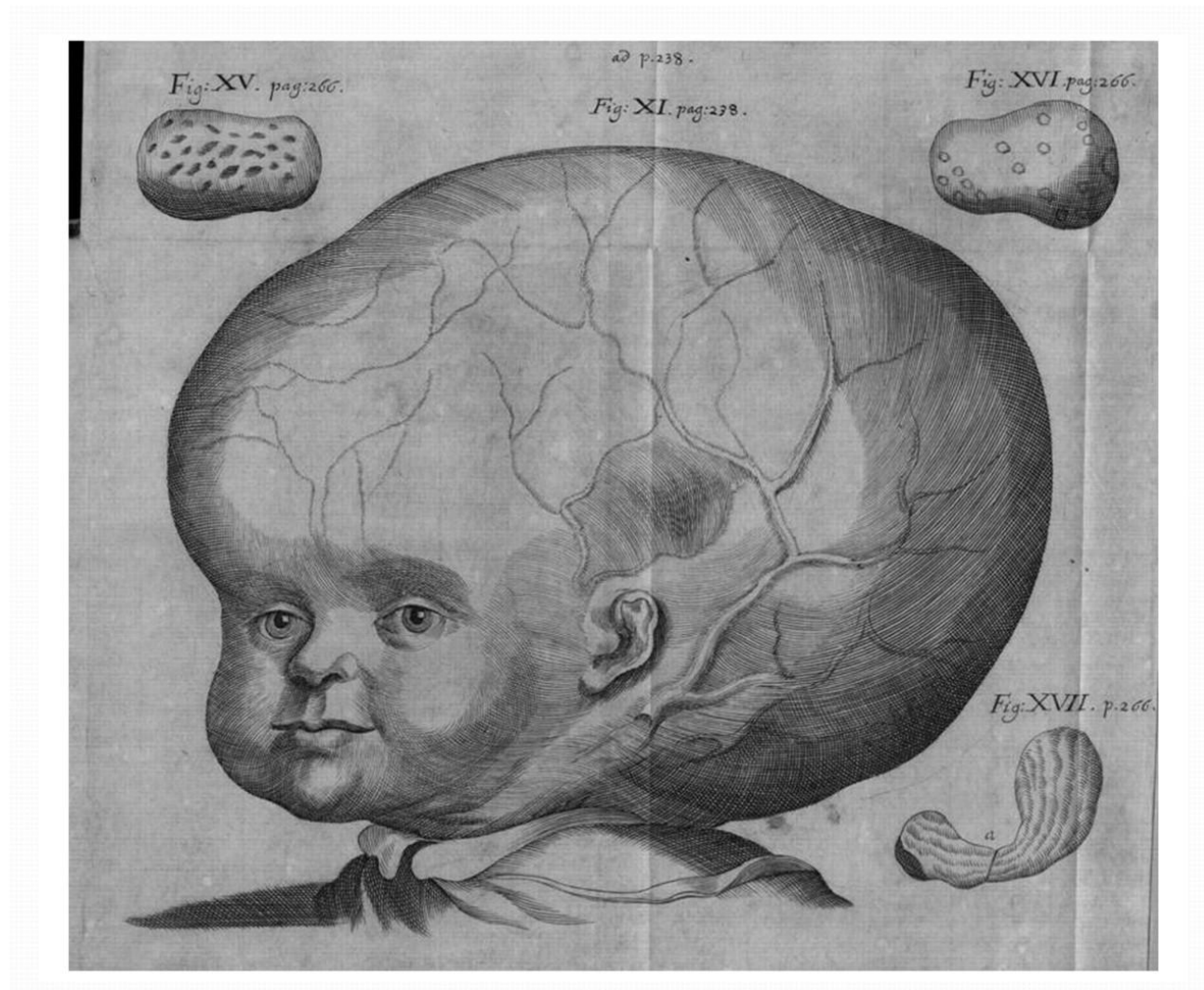
**geringe
Ischämietoleranz**

cerebrale Autoregulation

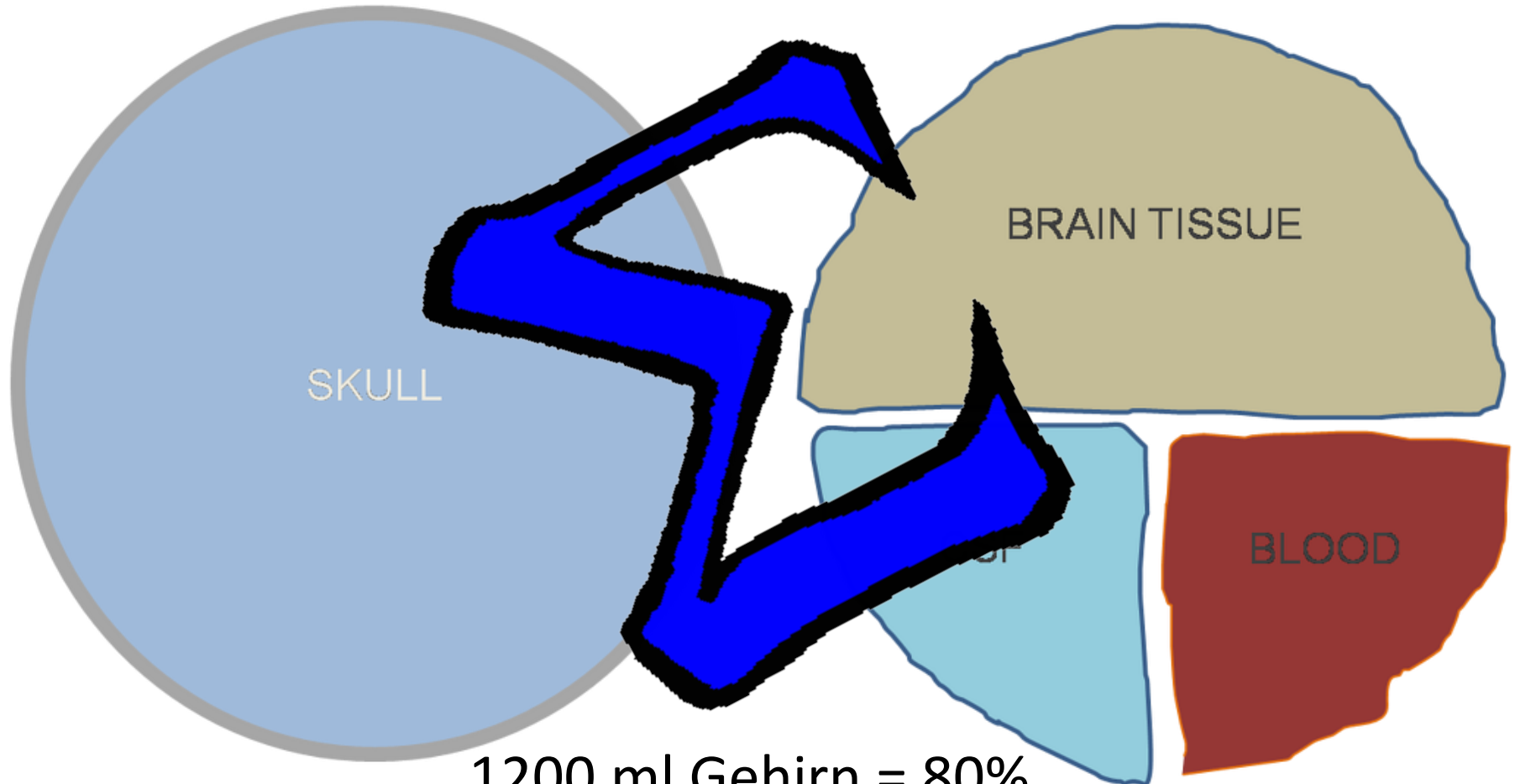
$$\text{CPP} = \text{MAP} - \text{ICP}$$



ICP – Intracranial pressure



Monro-Kellie-Doktrine

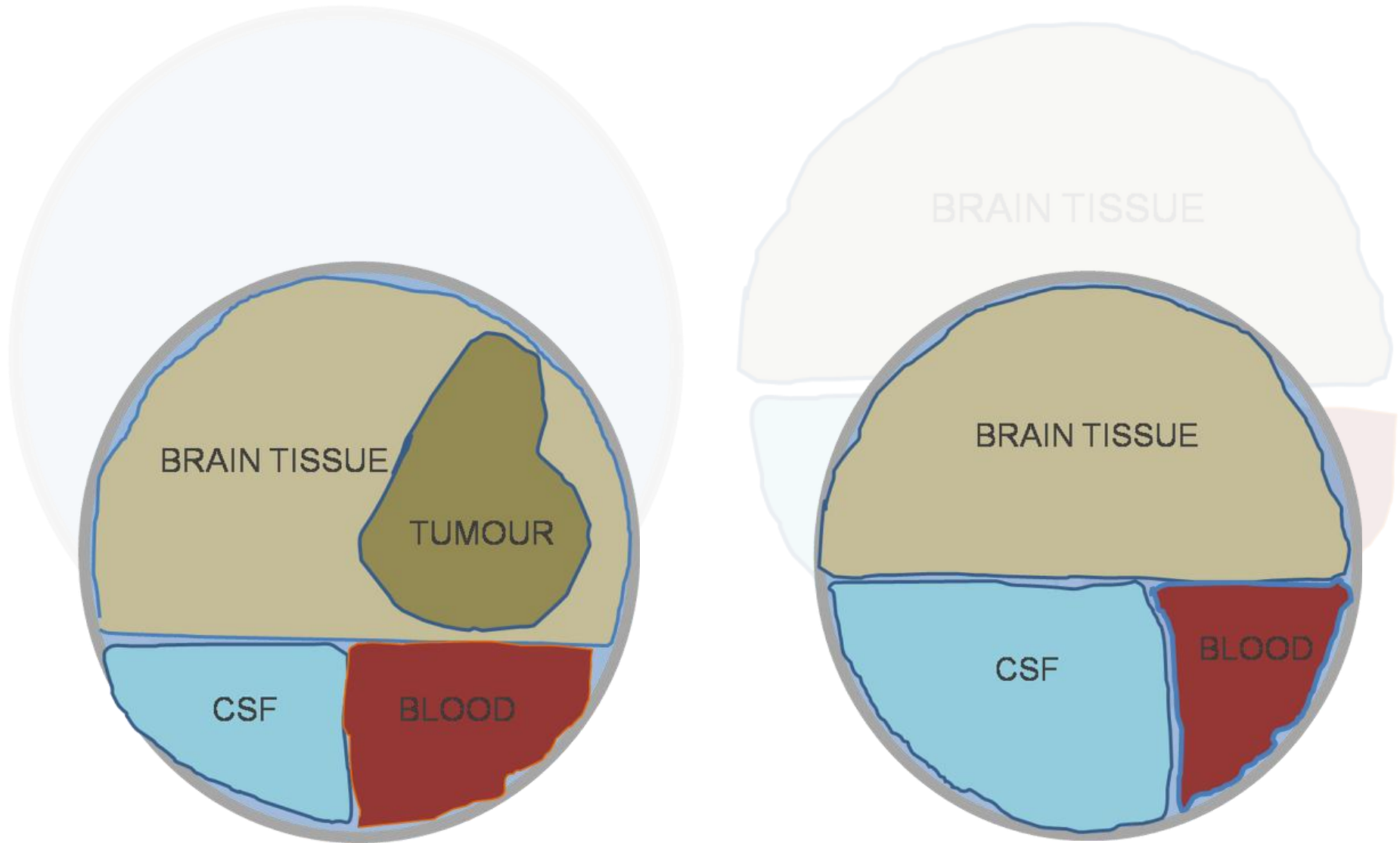


1200 ml Gehirn = 80%

150 ml Blut = 10%

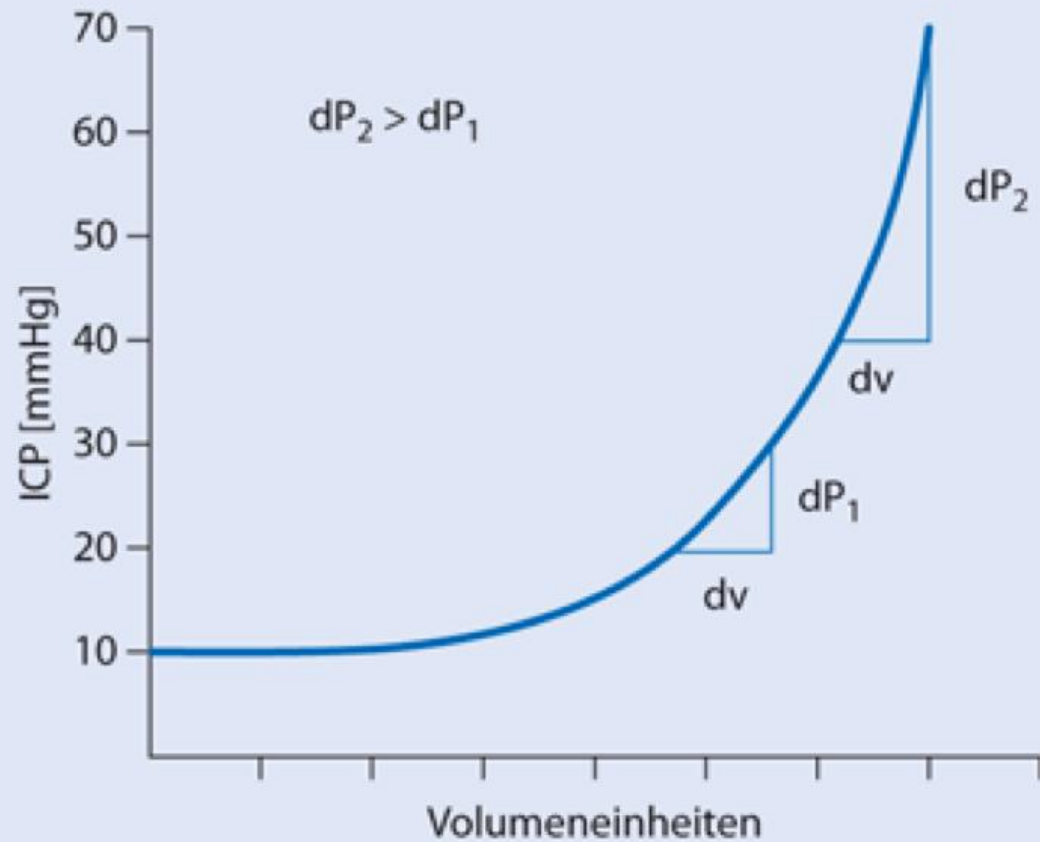
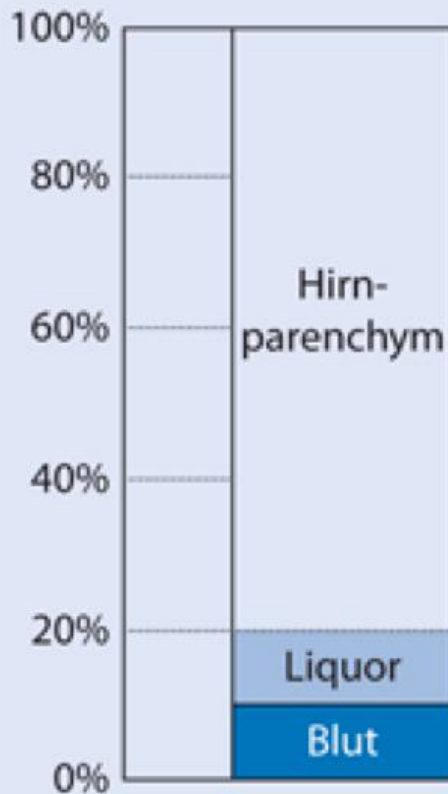
150 ml Liquor = 10%

Monro-Kellie-Doktrine



Monro-Kellie-Doktrine

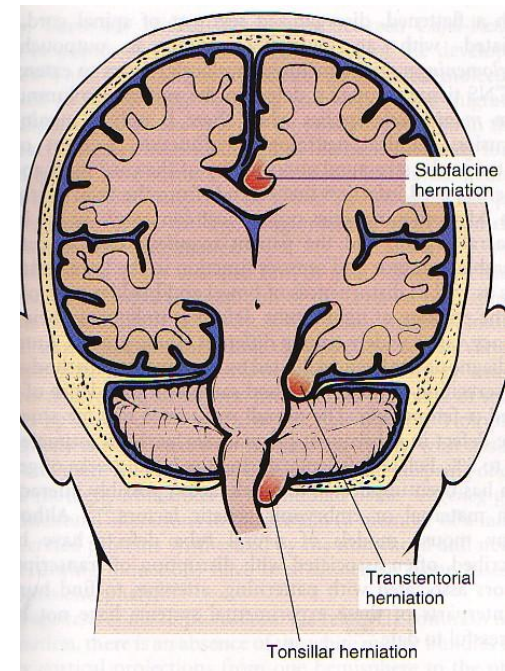
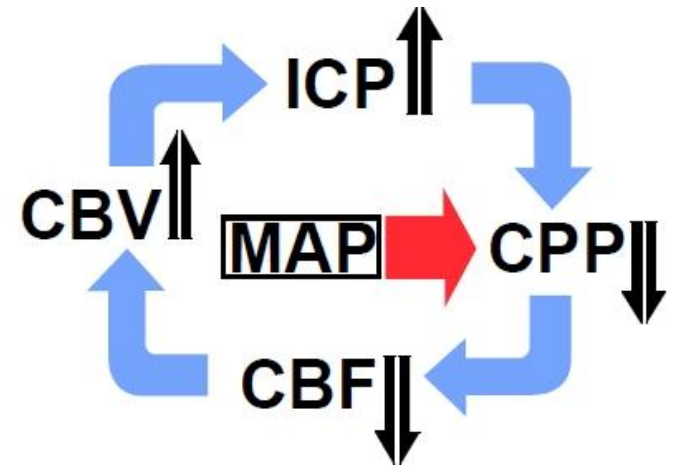
Liquorraum: Druck-Volumen-Beziehung



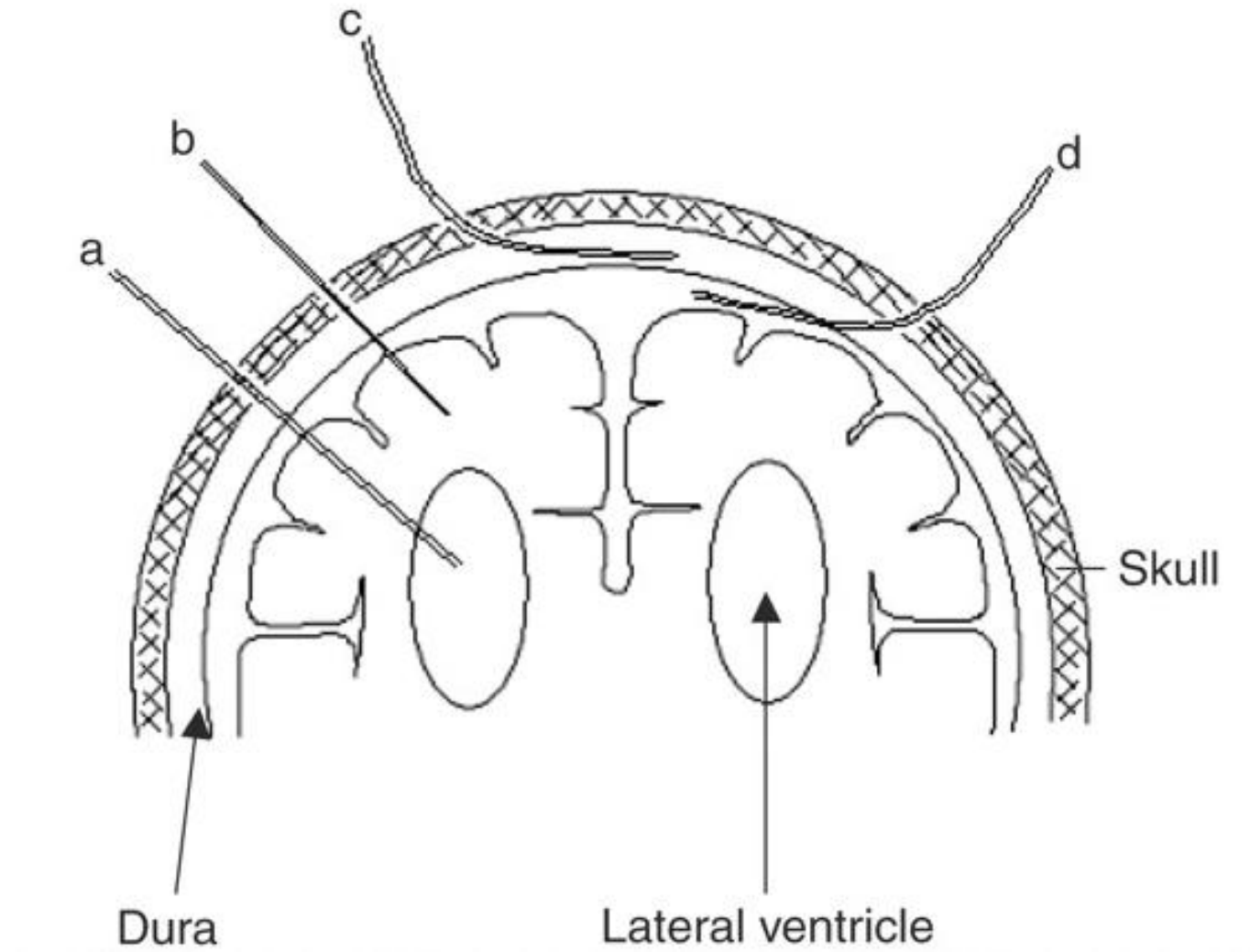
Symptome bei ICP Erhöhung

- Kopfschmerzen
- Übelkeit/ Erbrechen
- Zunehmende Bewußtseinsstörung
- Psychische Veränderungen

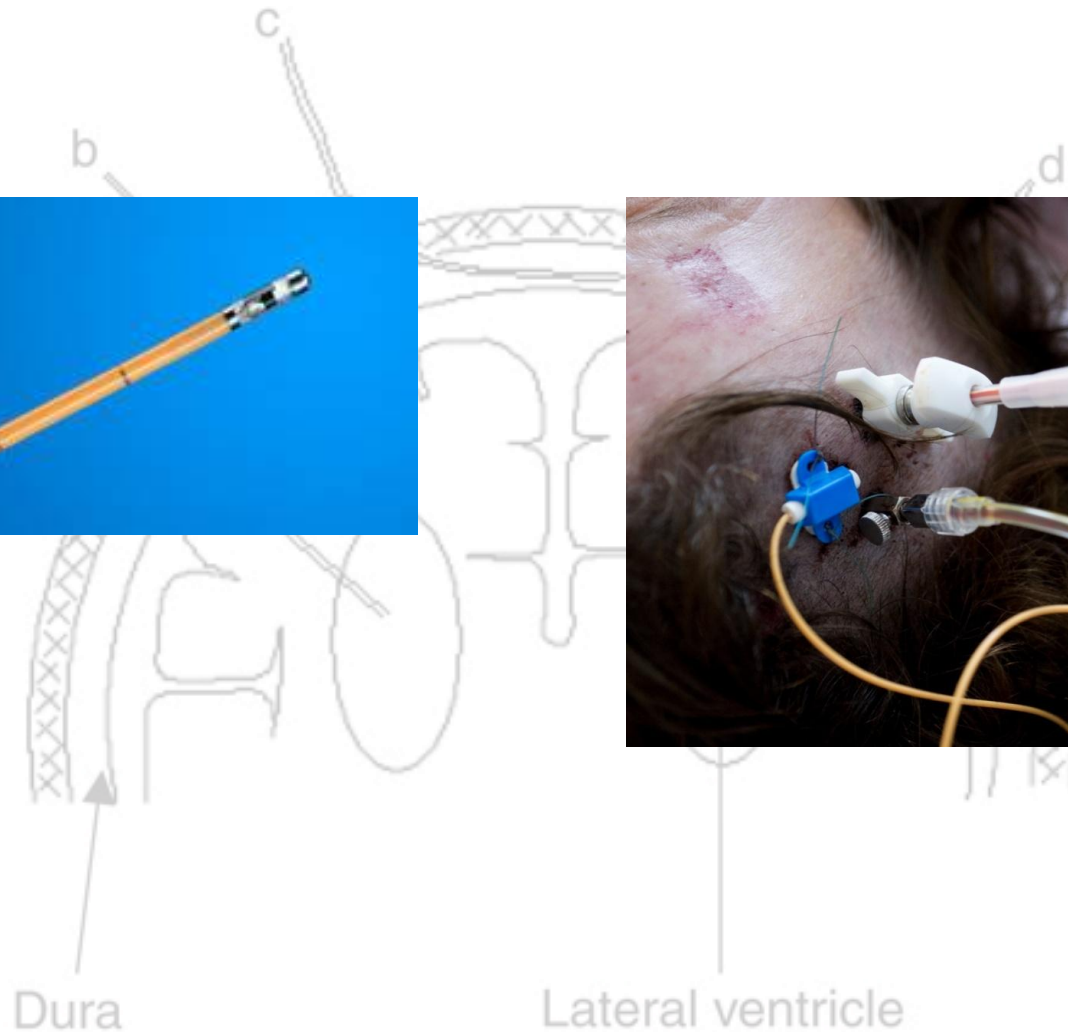
- Vegetative Symptome z.B. Bradykardie und hoher Blutdruck
- Pupillenstörungen z.B. einseitig weite Pupille
- Atemstörungen



ICP Messen



ICP Messen



The NEW ENGLAND JOURNAL *of* MEDICINE

ESTABLISHED IN 1812

DECEMBER 27, 2012

VOL. 367 NO. 26

A Trial of Intracranial-Pressure Monitoring in Traumatic Brain Injury

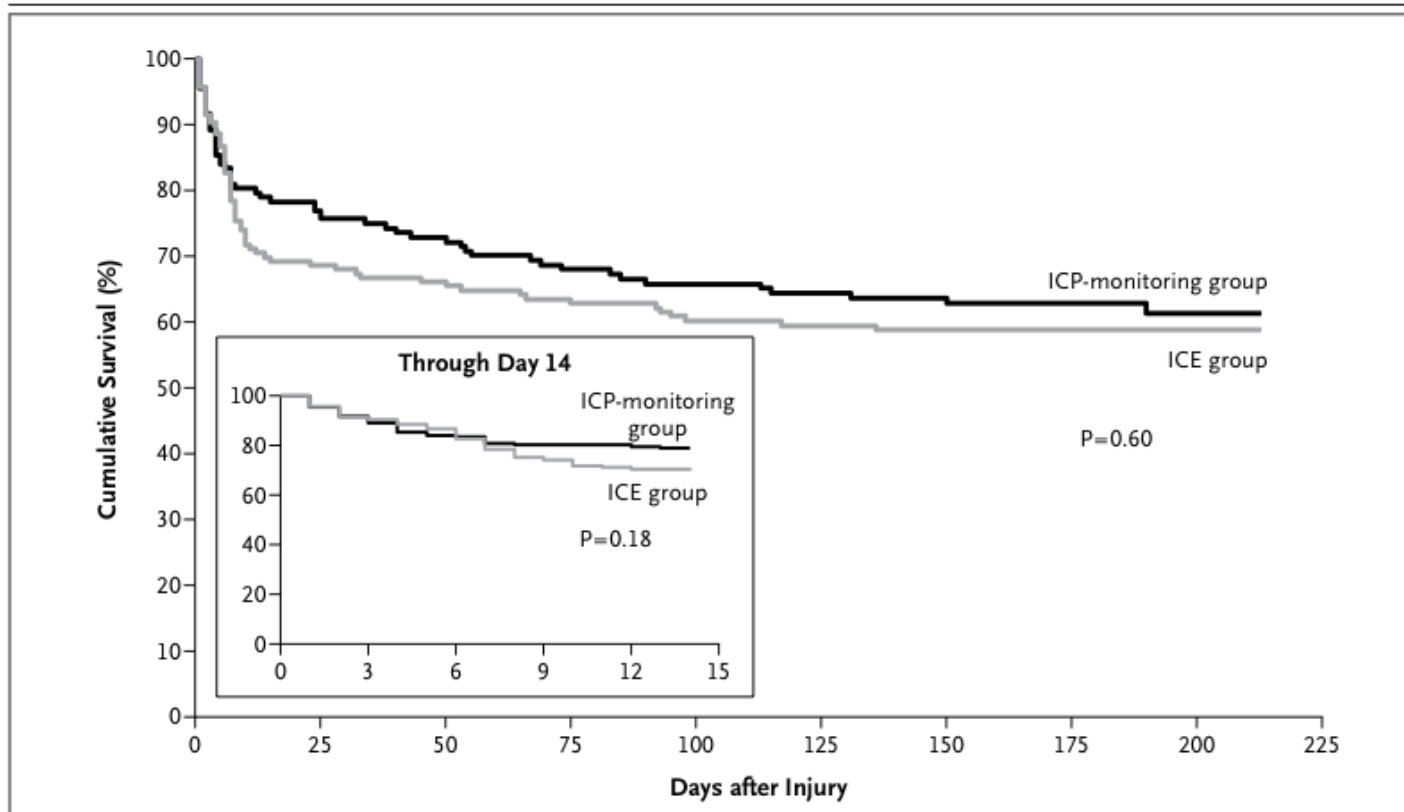
Randall M. Chesnut, M.D., Nancy Temkin, Ph.D., Nancy Carney, Ph.D., Sureyya Dikmen, Ph.D., Carlos Rondina, M.D., Walter Videtta, M.D., Gustavo Petroni, M.D., Silvia Lujan, M.D., Jim Pridgeon, M.H.A., Jason Barber, M.S., Joan Machamer, M.A., Kelley Chaddock, B.A., Juanita M. Celix, M.D., Marianna Cherner, Ph.D., and Terence Hendrix, B.A.

- admission to study hospital within 24 hours of injury
- closed head trauma
- Glasgow Coma Scale (GCS) < 8 on admission
- No foreign object in brain parenchyma
- Age > 12

ICP Messen



ICP Messen

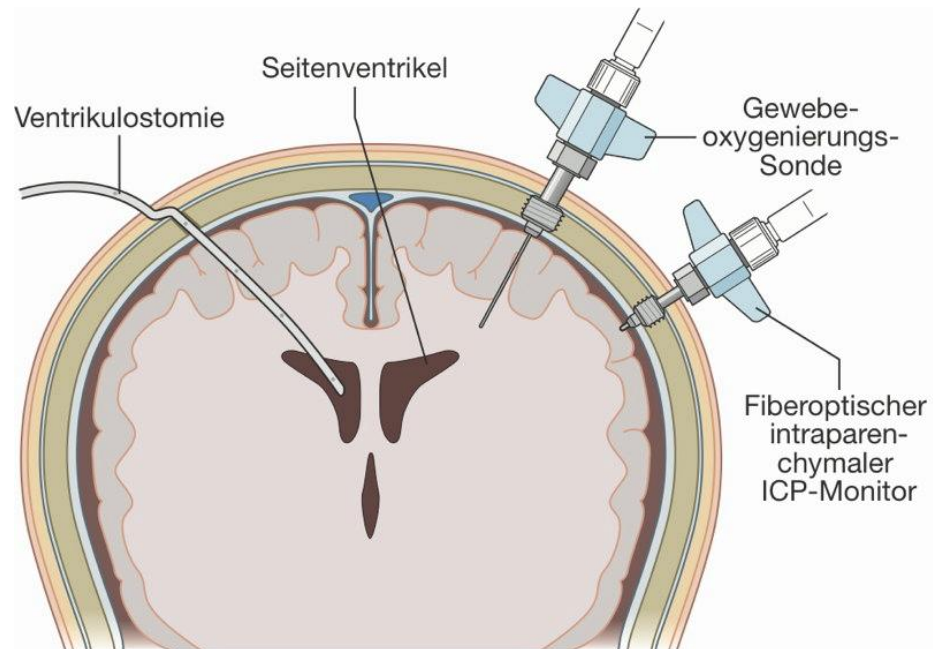


„For patients with severe traumatic brain injury, care focused on maintaining monitored intracranial pressure at 20 mm Hg or less **was not shown to be superior to care based on imaging and clinical examination.**“

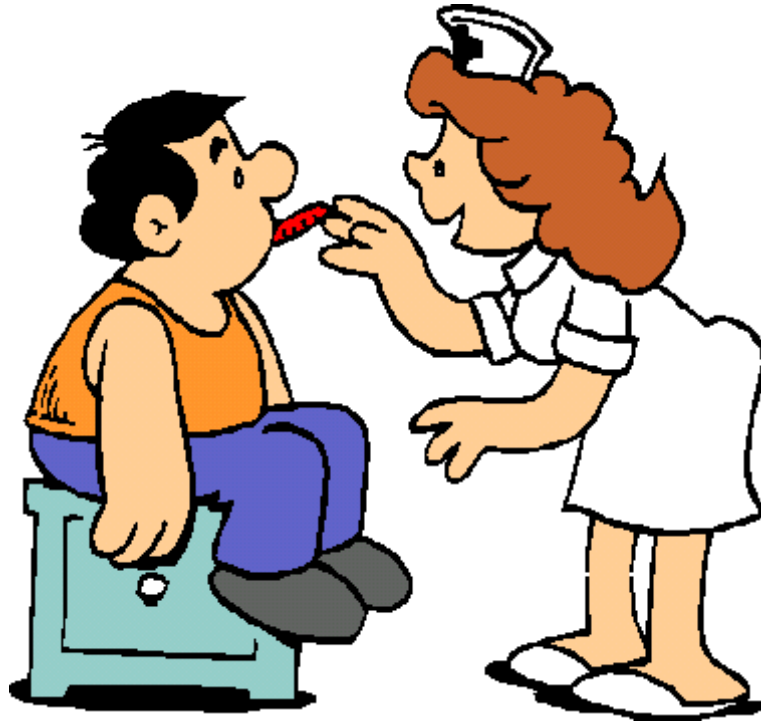
ICP Messen

- ICP Normwerte:
0-15 mmHg
- Kurzfristige Hirndruck-Erhöhrungen über 40mmHg führen am erkrankten Gehirn zu Schädigungen
(aufgehobene Autoregulation)
- Längerfristig erhöhte Werte zwischen 25-30 mmHg können fatale Folgen haben

$$1 \text{ cmH}_2\text{O} = 0,73 \text{ mmHg}$$



ICP Messen



ICP messen



Patienten behandeln

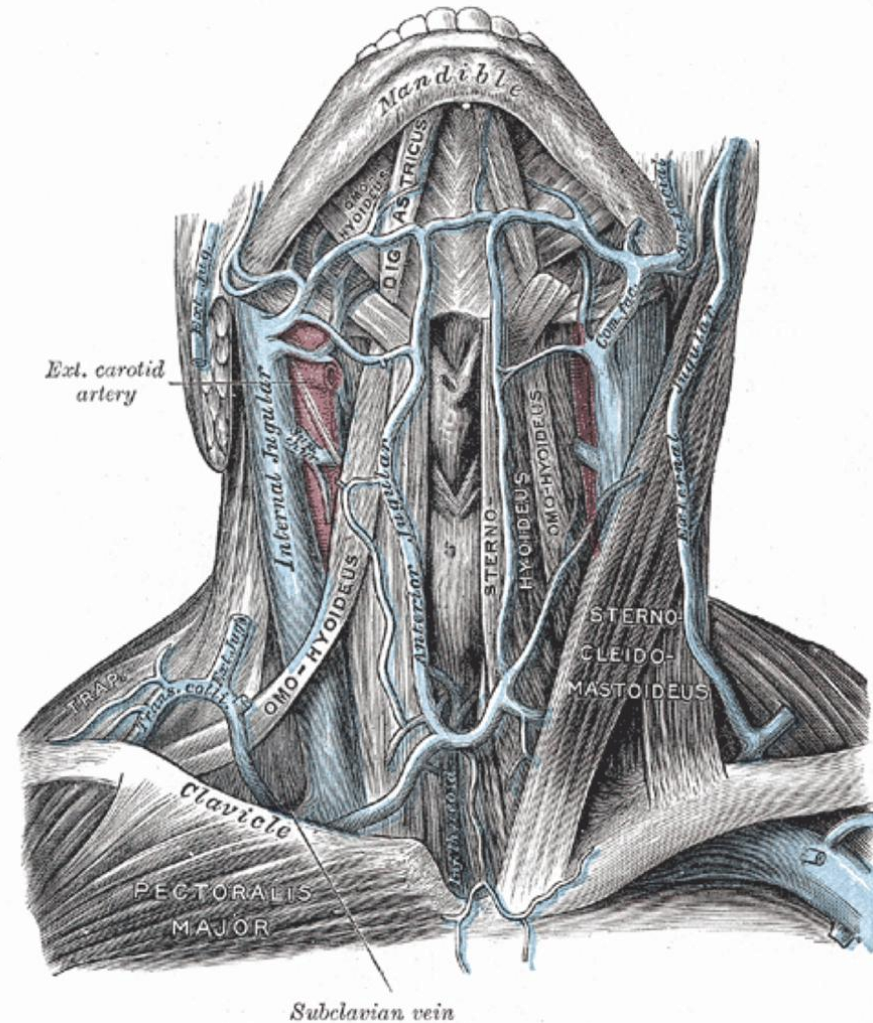
Grundlagen der Hirndrucktherapie

Achsengerechte Lagerung
ohne Kopfabknicken

Auf venösen Abfluss
achten!

Oberkörperhochlagerung

Gonzalez-Arias SM et al (1983) Neurosurgery

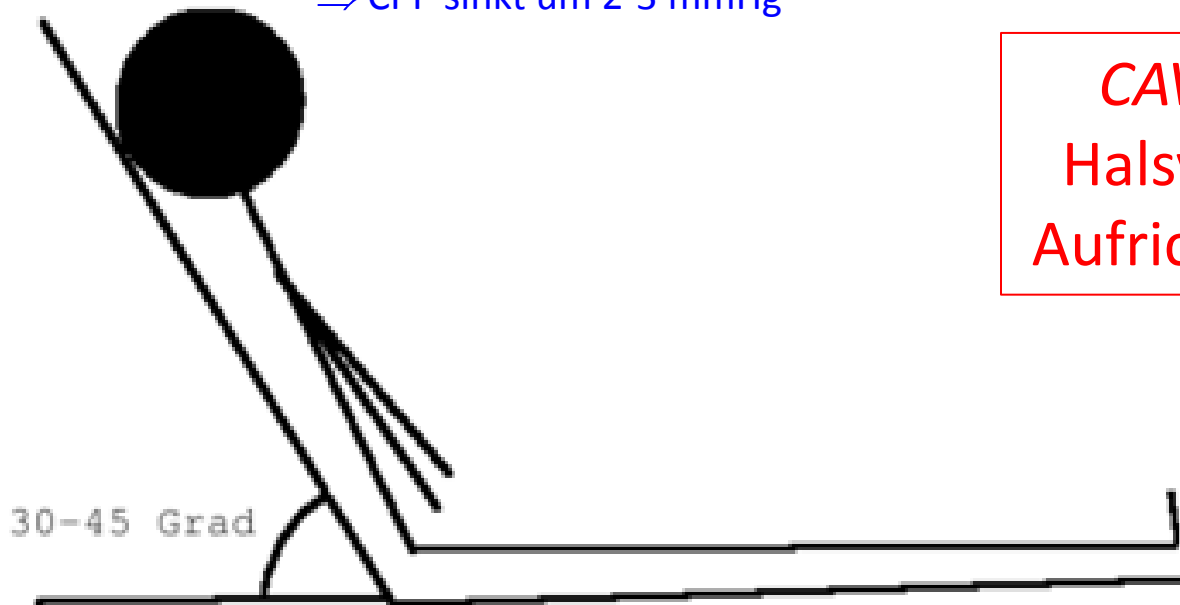


30° Oberkörperhochlagerung

Pneumonie-Rate sinkt

ICP sinkt

Pro 10° Oberkörperhochlagerung
⇒ ICP sinkt um 1 mmHg
⇒ CPP sinkt um 2-3 mmHg



Rosner MJ, Coley IB (1986) J Neurosurg
Feldmann Z et al. (1992) J Neurosurg
Ledwith MB et al. (2010) J Neurosci Nurs

CAVE: CPP sinkt bei zu hoher Lagerung

CAVE: Kollabieren der Halsvenen bei zu starker Aufrichtung (ICP ANSTIEG)

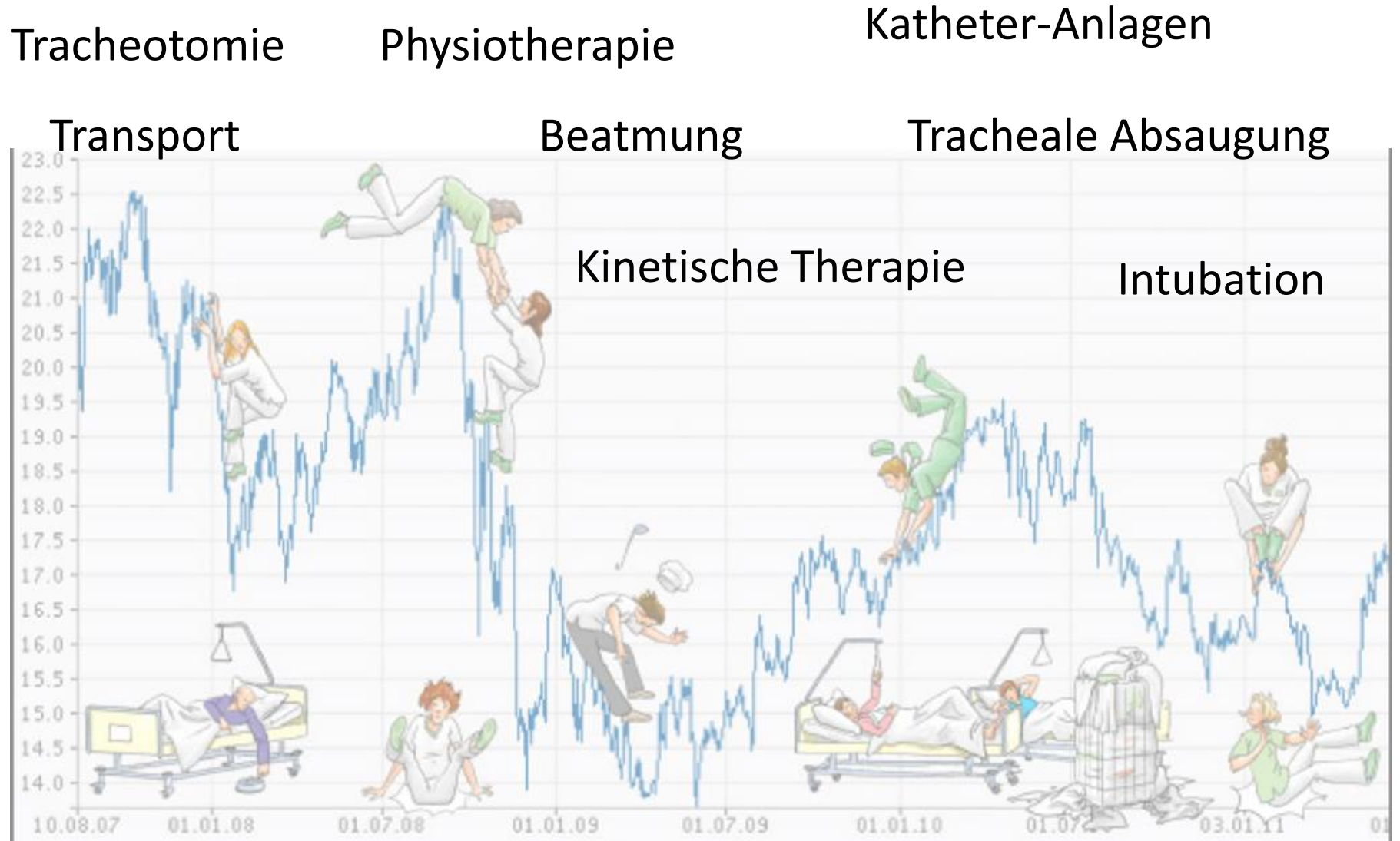
Patienten mit kritischer ICP Erhöhung



TOUCH
MINIMAL

By / Ijfke Ridgley

cerebrale Autoregulation



Hohe Anzahl von
Patiententransporten
Great Intensity

Kritischen Phase der
Erkrankung





ORIGINAL RESEARCH

Effect of Early Physiotherapy on Intracranial Pressure and Cerebral Perfusion Pressure

Christian Roth • Hubertus Stitz • Anas Kalhout • Jens Kleffmann •
Wolfgang Deinsberger • Andreas Ferbert

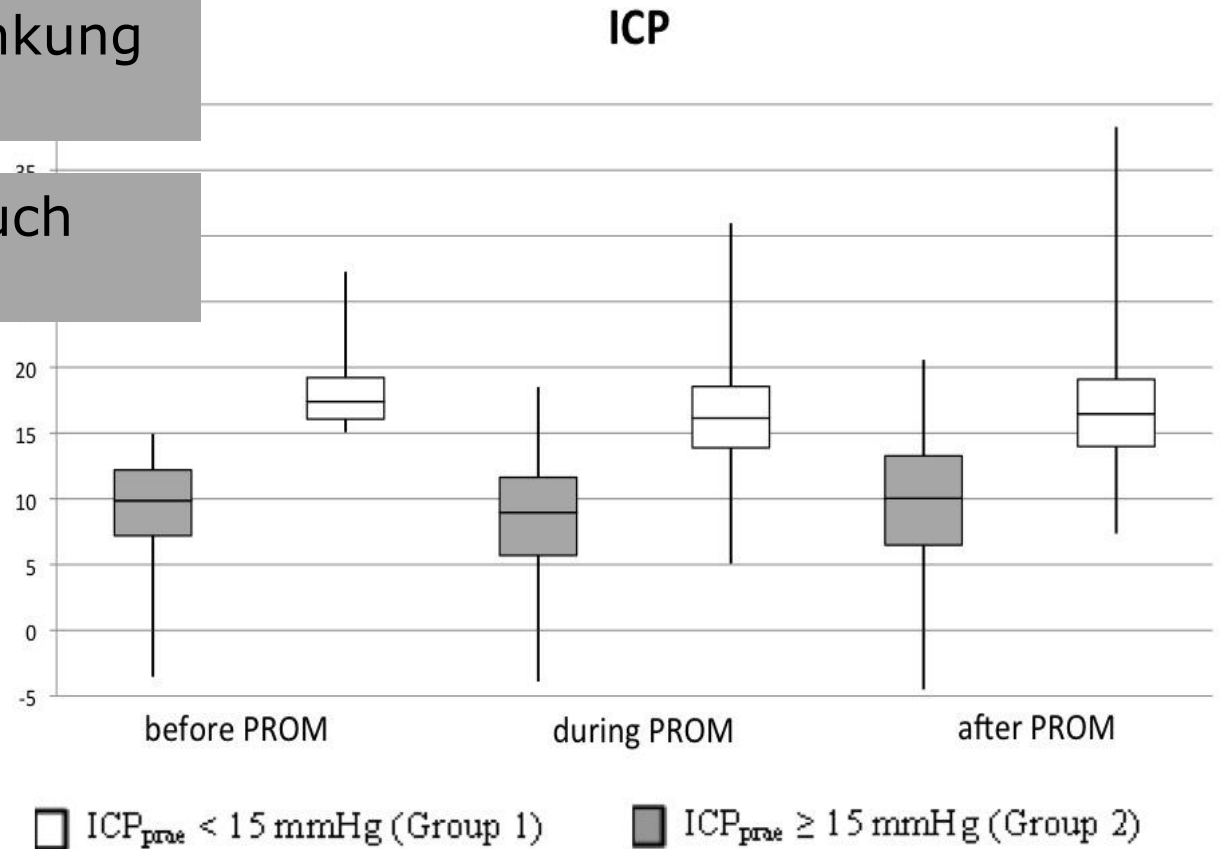
- 84 Patienten
 - Beatmet, Ramsay 6: 85%,
 - Analgosedierung 72%
- 298 Behandlungen
- Passive Bewegung über 26 Min.



PHYSIOTHERAPIE und ICP

Signifikante ICP Senkung
um 1-2mmHg

Kein Therapie-Abbruch
notwendig



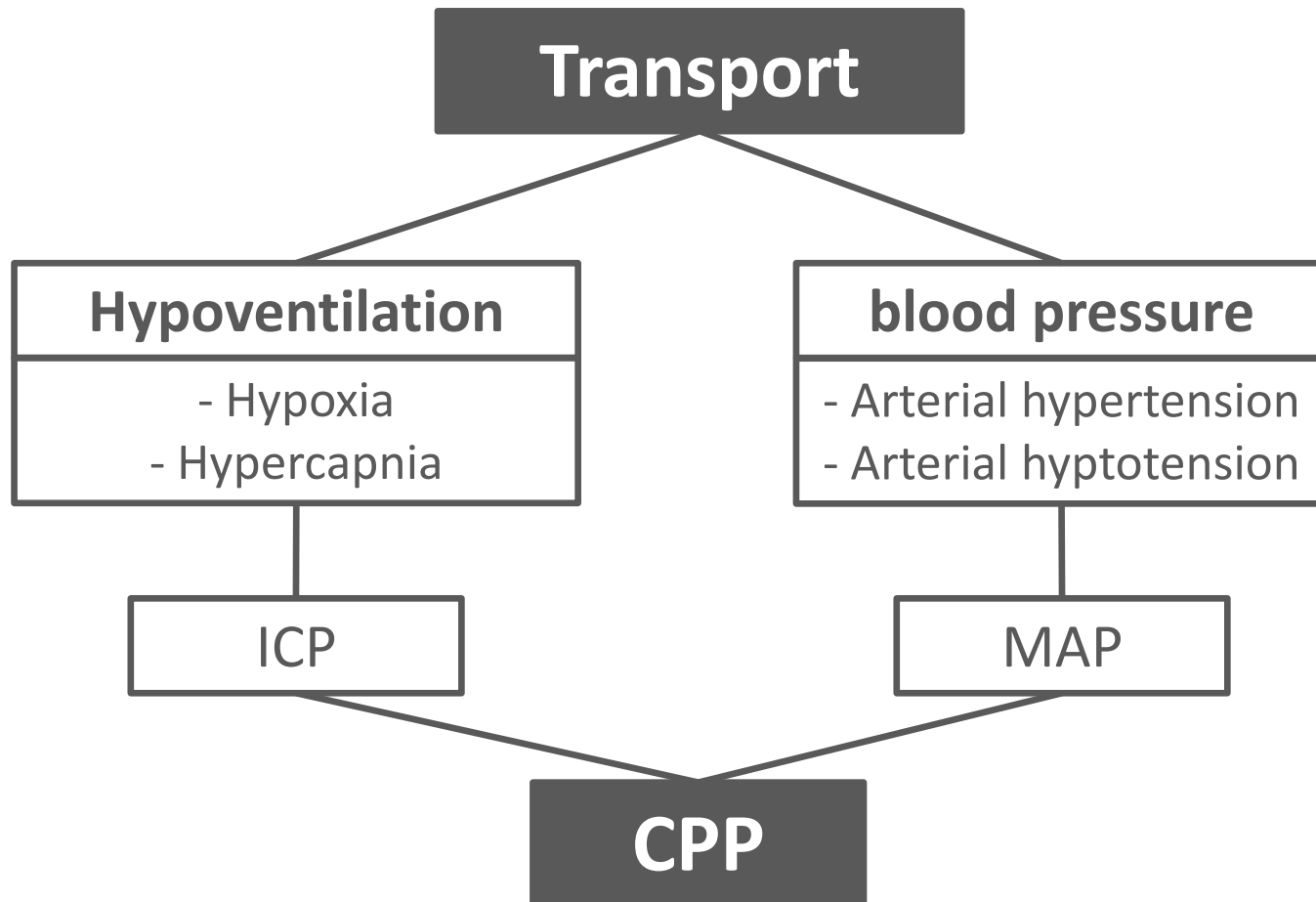
Affektion ICP & CPP

Bei 262 intrahospital Transporten kritisch kranker Patienten in 45,8% der Fälle zu Komplikationen in 16,8% der „serious adverse events“

Zur Vermeidung von Komplikationen existieren zahlreiche Empfehlungen



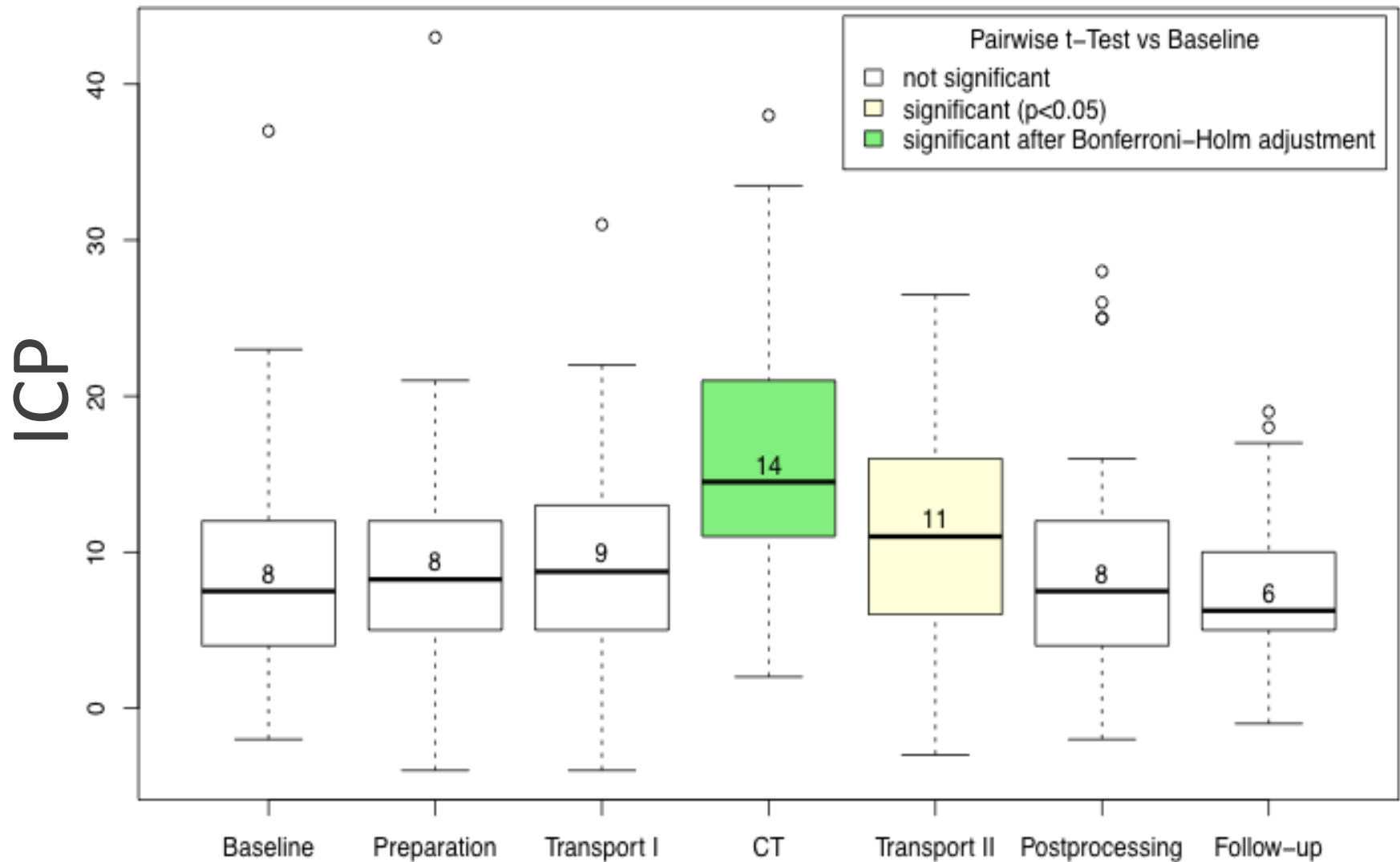
Affektion ICP & CPP



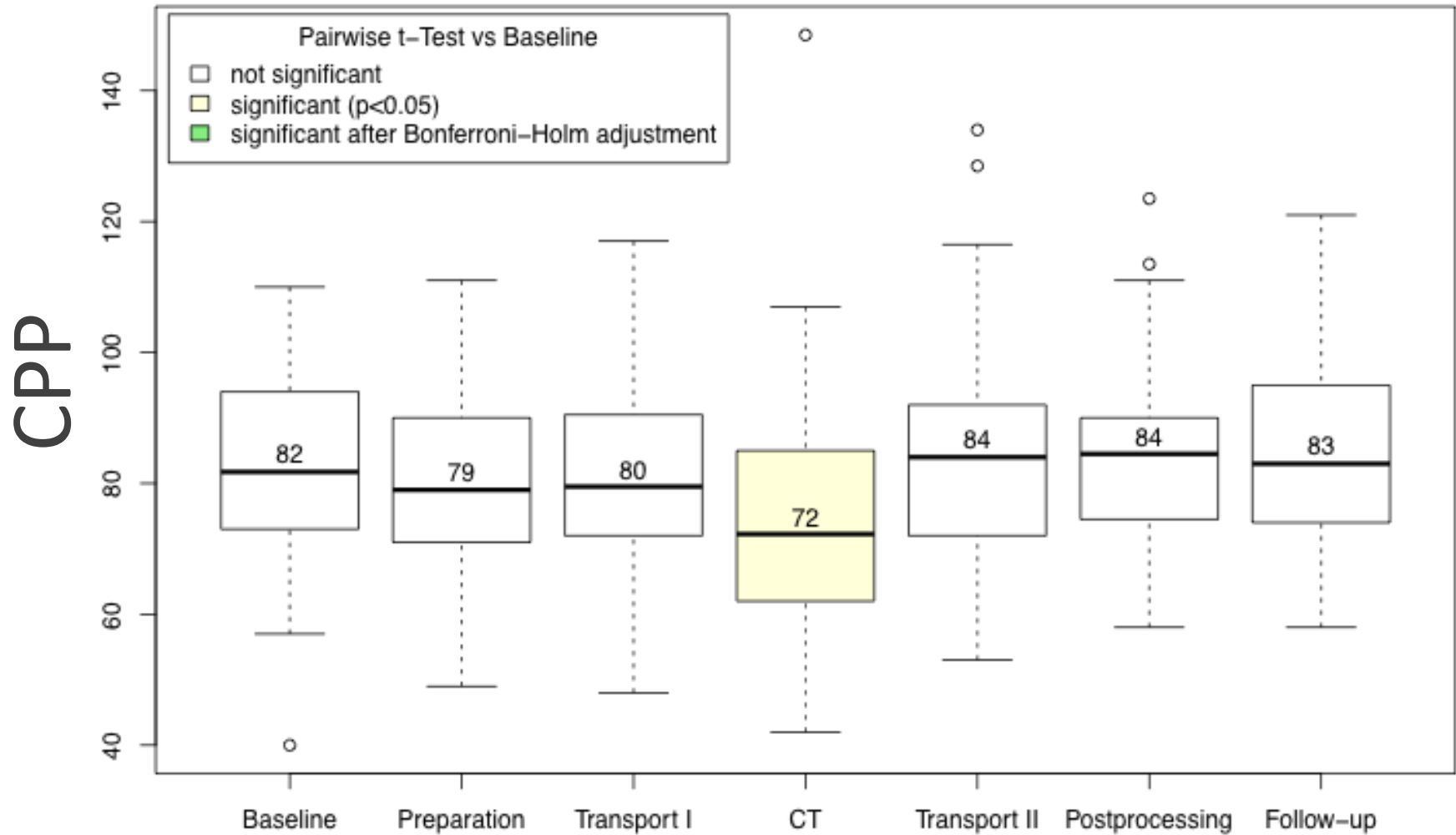
Moraine J, Brimiouille S, Kahn R (1991) Effects of respiratory therapy on intracranial pressure. **J Crit Care**

Peerless JR, Snow M (1995) The effect of fiberoptic bronchoscopy on cerebral hemodynamics in patients with severe head injury. **Chest**

ICP bei intrahospital Transporten

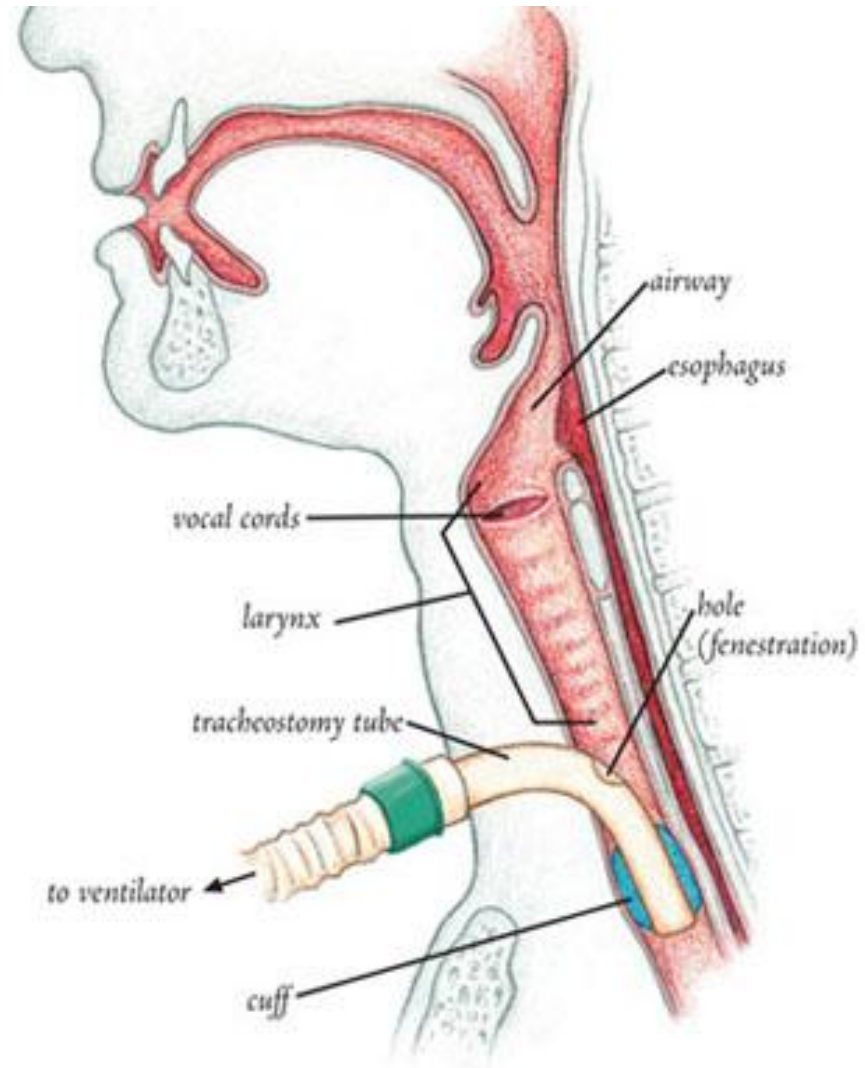


CCP bei intrahospital Transporten

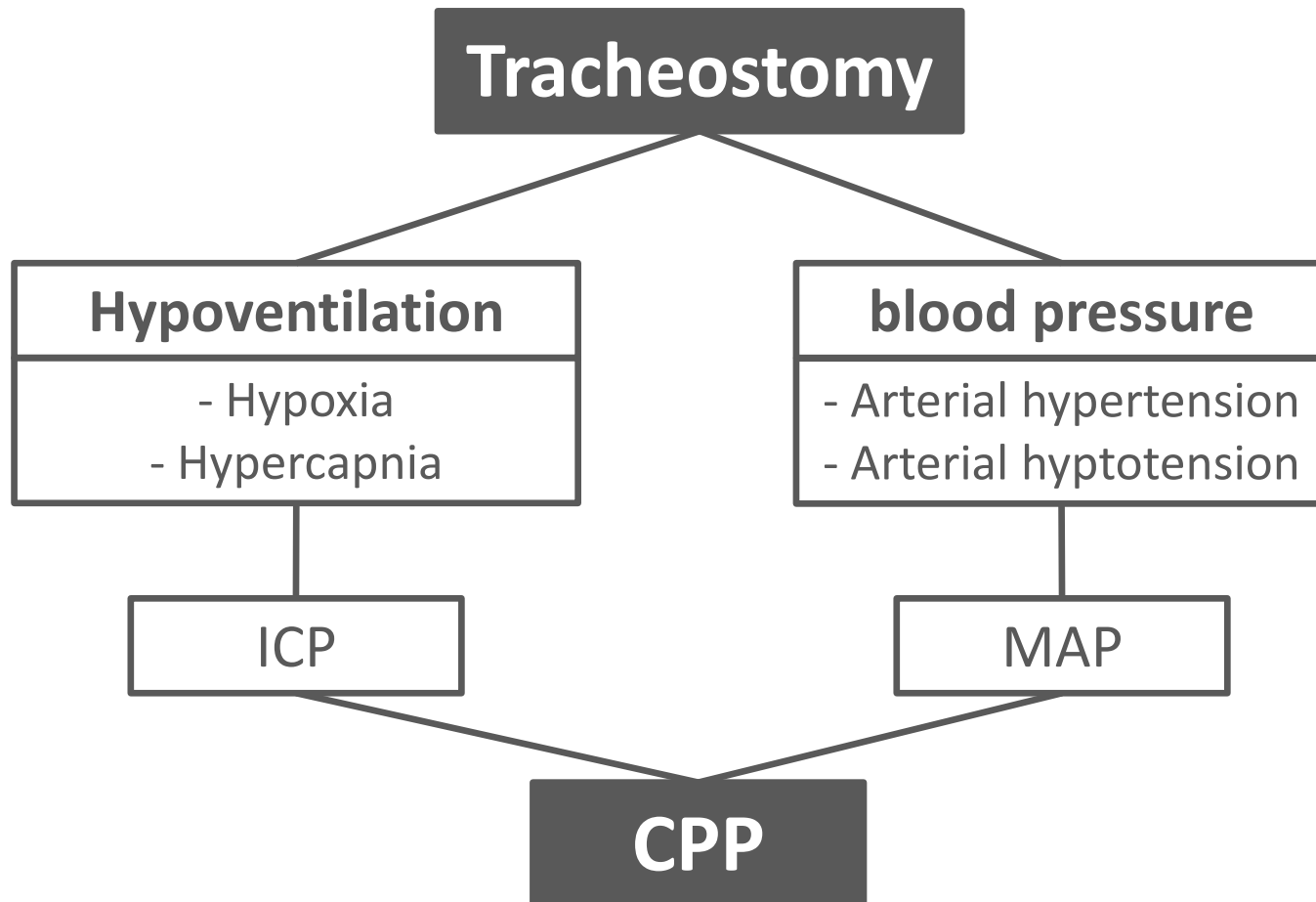


Ventilation

Langzeitbeatmung



Ventilation

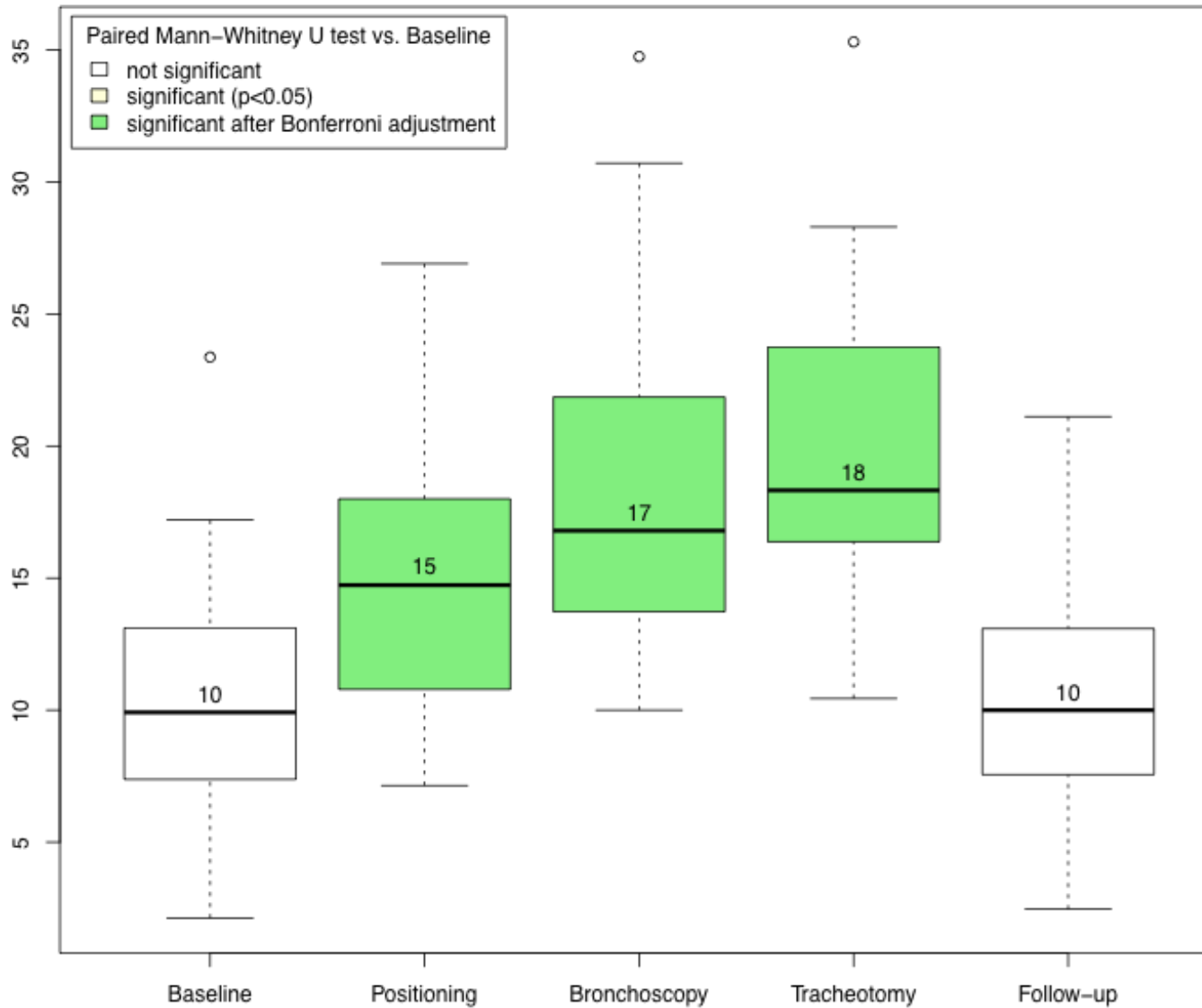


Moraine J, Brimiouille S, Kahn R (1991) Effects of respiratory therapy on intracranial pressure. **J Crit Care**

Peerless JR, Snow M (1995) The effect of fiberoptic bronchoscopy on cerebral hemodynamics in patients with severe head injury. **Chest**

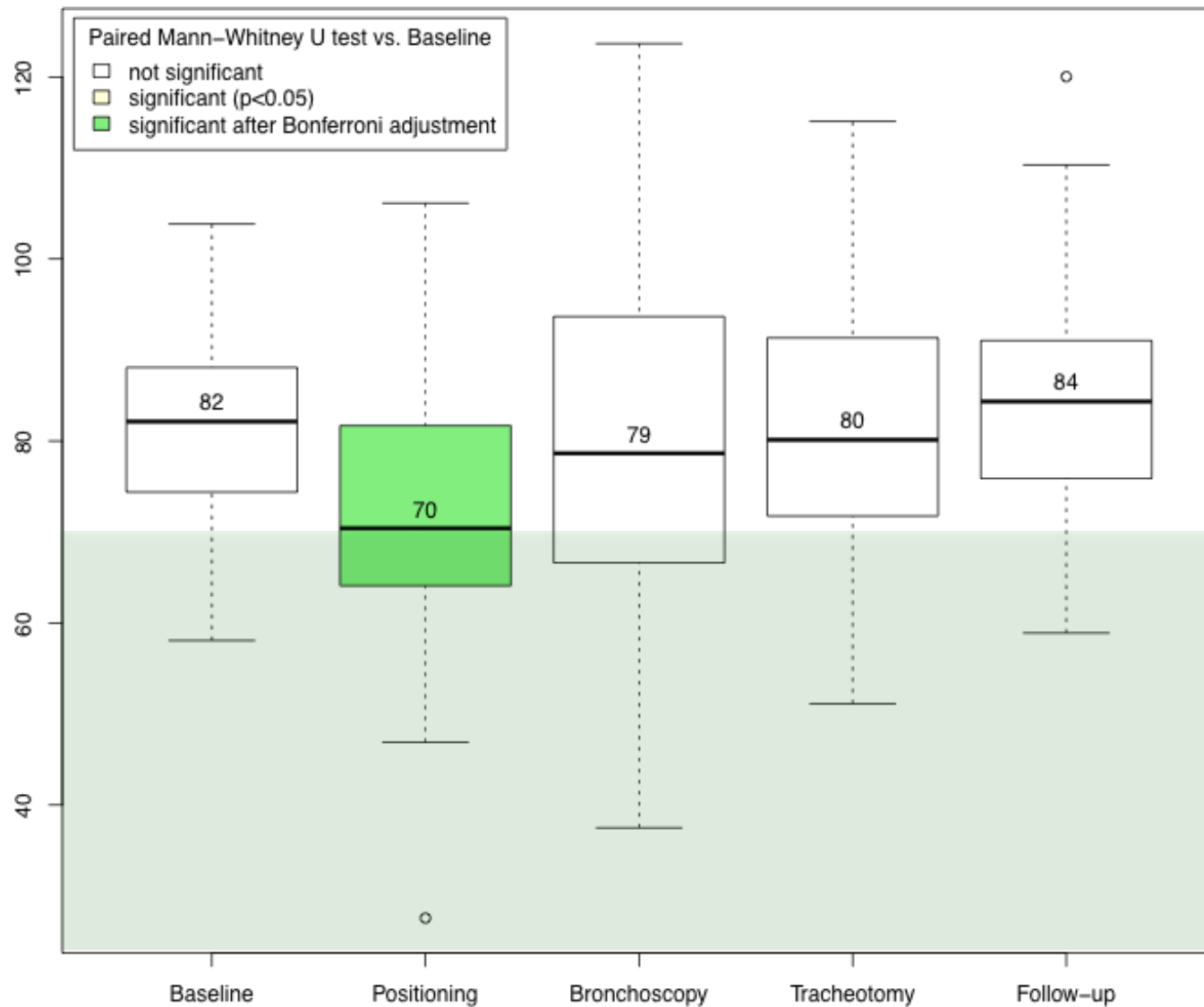
Reilly PM, Anderson HC (1995) Occult hypercapnia. Occult hypercapnia. An unrecognized phenomenon during percutaneous dilational tracheostomy. **Chest**

ICP während Tracheotomie

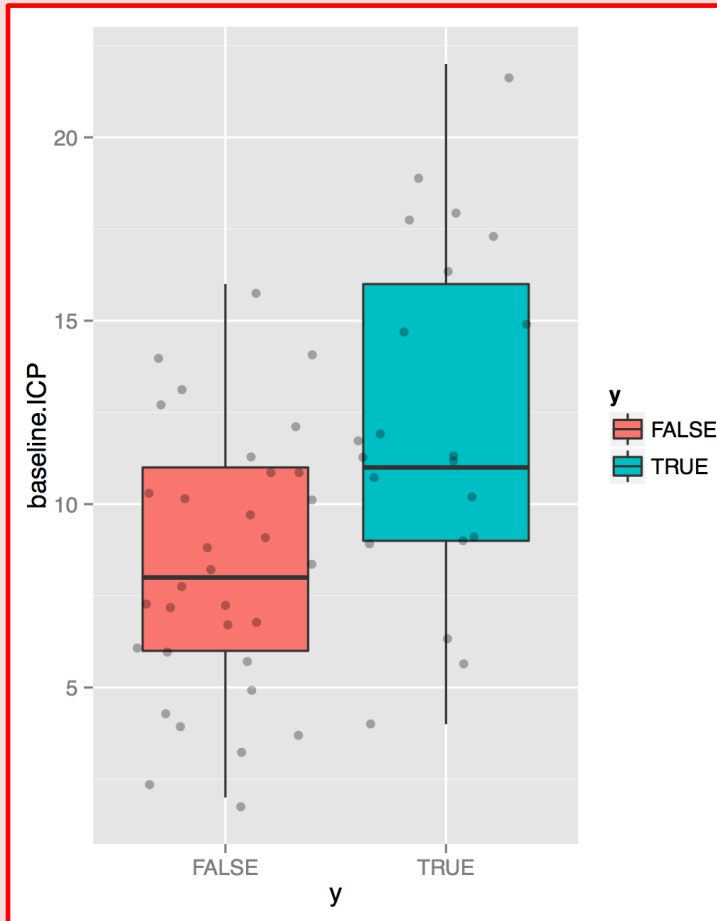


Kleffmann et al. Effect of Percutaneous Tracheostomy on Intracerebral Pressure and Perfusion Pressure in Patients with Acute Cerebral Dysfunction (TIP Trial): An Observational Study. **Neurocritical Care (2012)**

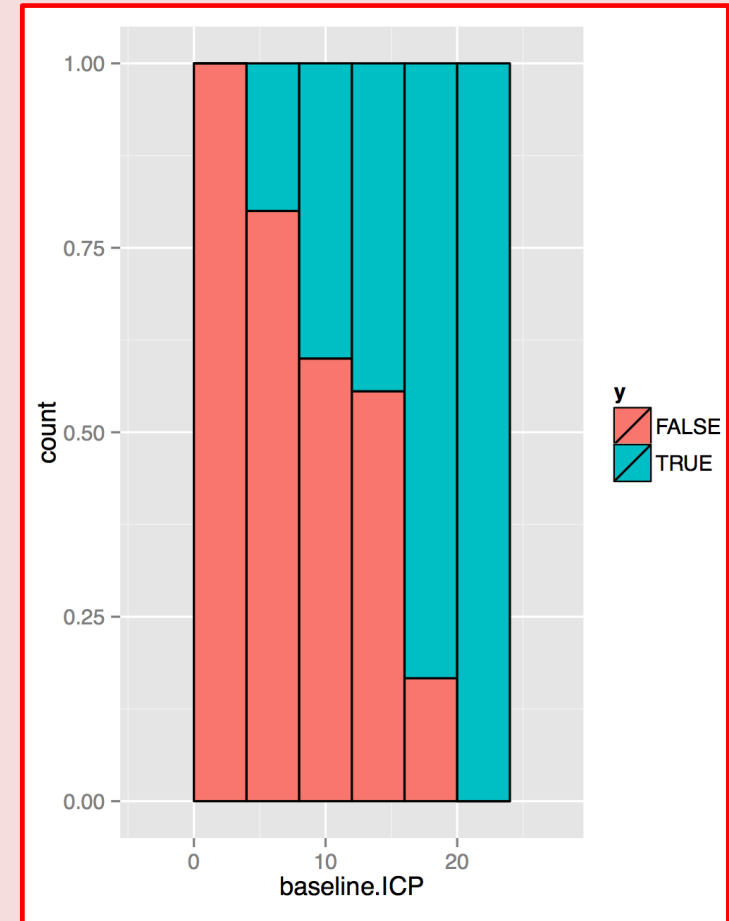
Entwicklung CPP



Risikofaktor Baseline ICP



Box plot ICP



Mosaic plot ICP

Tracheotomie bei akuter Hirnschädigung



Kontinuierliches Monitoring

ICP, MAP und CPP



**Kein Benefit bei
Frühtracheotomie**



Baseline ICP < 15mmHg

Hirndrucktherapie durch Hyperventilation?

$p\text{CO}_2 \downarrow$

Vasokonstriktion

ICP $\downarrow$



=> Reduktion des CBF und konsekutive Verminderung der O_2 Zufuhr v.a. in geschädigten Gebieten

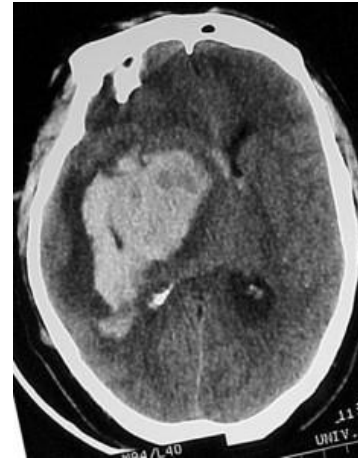
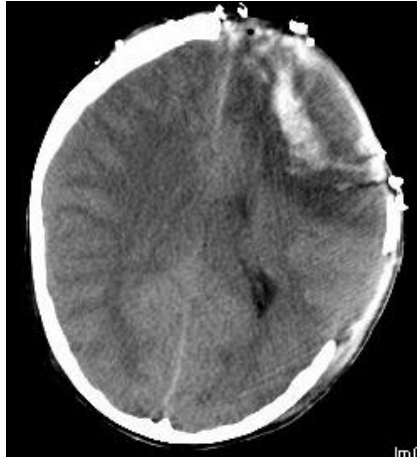
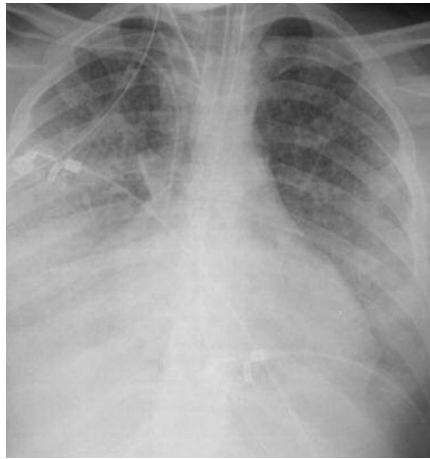
Keine längerfristige Hyperventilation

milde Hyperventilation: $p\text{CO}_2$ 35-37 mmHg

PEEP bis 15 mmHg problemlos anwendbar

Na ⁺	137	mmol/L
Cl ⁻	107	mmol/L
Ca ²⁺	1.36	mmol/L
Hct	27	%
Glu	144	mg/dL
Lac	1.0	mmol/L
Häm-Oxymetrie		
Hb	9.1	g/dL
SpO ₂	95.7	%

Lunge und Hirn / Hirn und Lunge



Ca. 20% ARDS bei SAB-Patienten

Gruber A. et al. (1999) J Neurosurg

Intubation

- Transienter ICP Anstieg
- CAVE: RR-Einbruch unter Narkoseeinleitung!!

Bruney RG, Winn R (1975) Anesth Analg

Endotracheales Absaugen

- Transienter ICP Anstieg (Mittel: 2 Minuten)
- Signifikant höherer ICP Anstieg und niedriger pO₂ während offener Absaugung (im Vergleich zur geschlossenen Absaugung)

Ugras GA, Aksoy G (2012) J Neurosci Nurs
Kerr ME et al (1999) Crit Care Med
Gemma M et al. (2002) J Neurosurg Anesthesiol

Fieberoptische Bronchoskopie

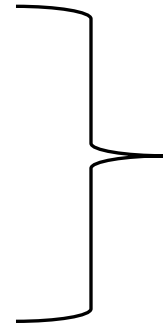
- Transienter ICP Anstieg trotz Analgosedierung und Relaxation
- Gleichzeitiger MAP (und CPP) Anstieg

Peerless JR et al. (1995) Chest

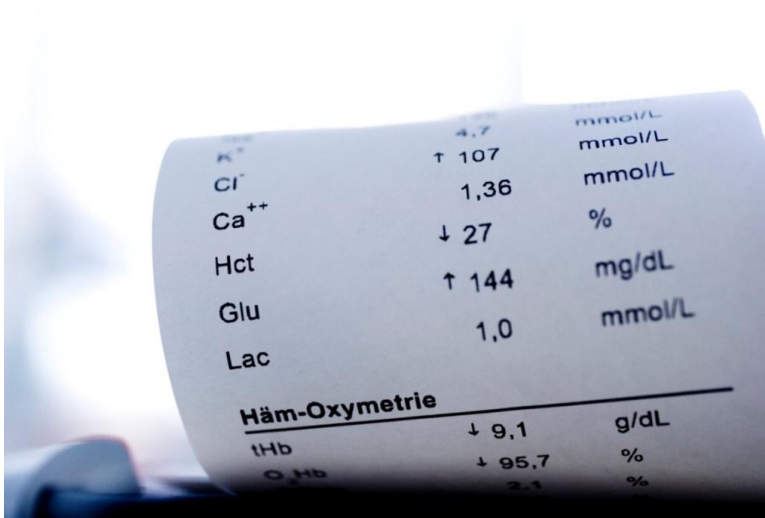
Lunge und Hirn / Hirn und Lunge

ARDS Beatmung:

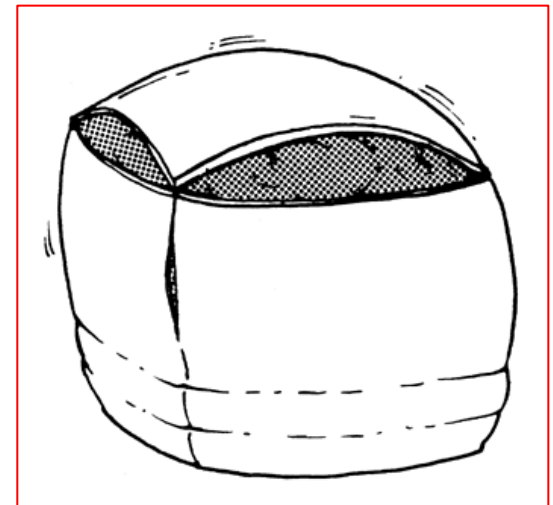
- Hoher PEEP
- Kleine Tidalvolumen
- Inverse Ventilation
- Permissive Hyperkapnie



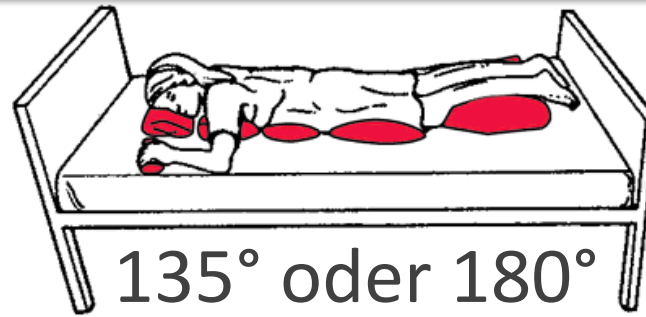
ICP Anstieg!



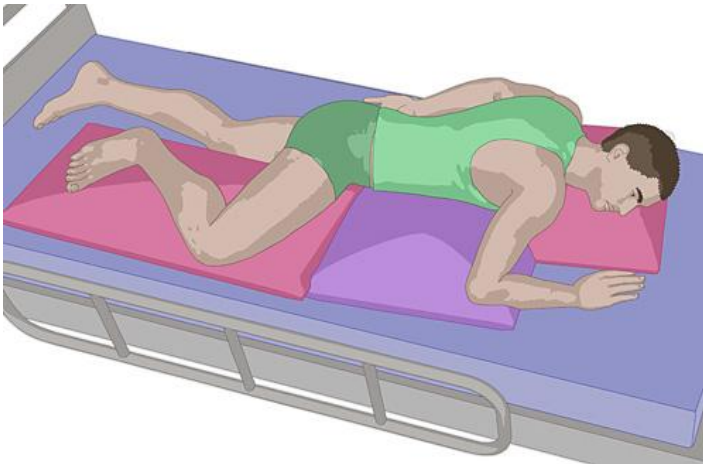
K ⁺	4,7	mmol/L
Cl ⁻	↑ 107	mmol/L
Ca ⁺⁺	1,36	mmol/L
Hct	↓ 27	%
Glu	↑ 144	mg/dL
Lac	1,0	mmol/L
Häm-Oxymetrie		
tHb	↓ 9,1	g/dL
O ₂ Hb	↑ 95,7	%
	2,1	%



Prone position - Bauchlage



135° oder 180°



„good lung down“



Prone Position

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Prone Positioning in Severe Acute Respiratory Distress Syndrome

PROSEVA

Multizentrisch, randomisiert

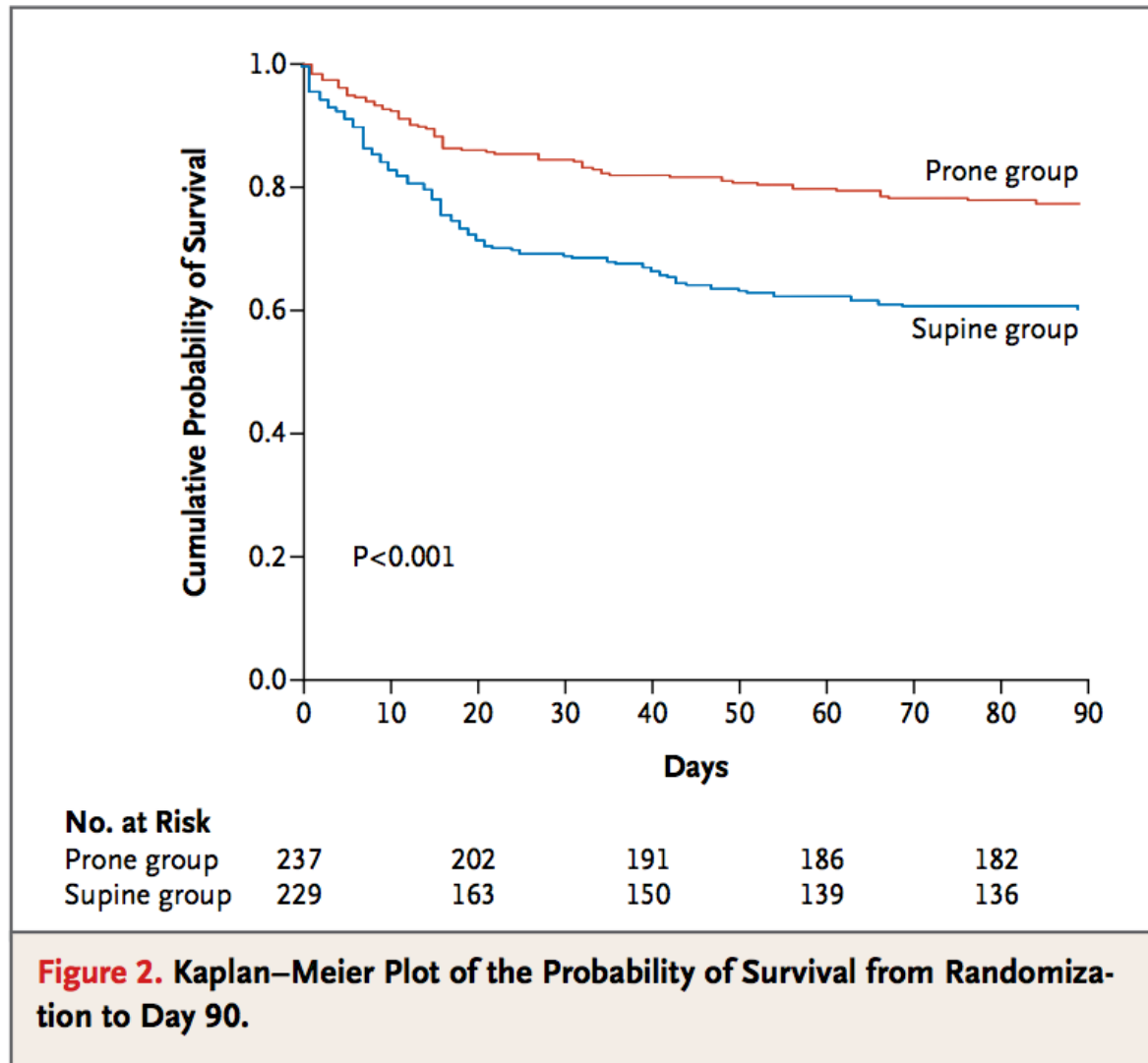
466 Patienten mit ARDS

(Horowitz > 150, FiO₂ > 0,6, PEEP 5 cmH₂O)

Vergleich von Rückenlage vs. Bauchlage
(mind. 16h)

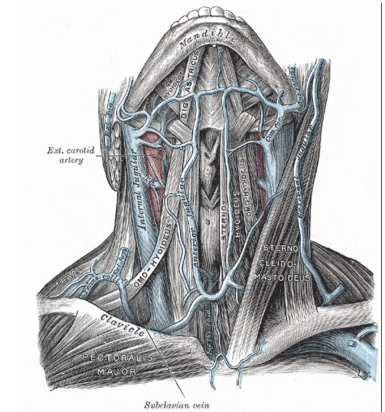
Prone Position

PROSEVA



Prone Position

- Keine achsengerechte Lagerung
- Analgosedierung notwendig
- Klinische Beurteilbarkeit eingeschränkt
- Druckmydriasis
- Allgemeine Komplikationen:
 - Katheterdislokation
 - Probleme bei Notfallmaßnahmen
 - Ulcera, Erblindung etc.



Prone position - ICP

Neurologic Critical Care

Prone position in subarachnoid hemorrhage patients with acute respiratory distress syndrome: Effects on cerebral tissue oxygenation and intracranial pressure*

Andrea Reinprecht, MD; Manfred Greher, MD; Stefan Wolfsberger, MD; Wolfgang Dietrich, MD;
Udo M. Illievich, MD; Andreas Gruber, MD

16 Patienten (SAB und ARDS), retrospektiv:

- pO₂-Anstieg
- ICP-Erhöhung ($9,3 \pm 5,2$ mmHg zu $14,8 \pm 6,7$ mmHg)
- CPP-Abfall ($73 \pm 10,5$ mmHg zu $67,7 \pm 10,7$ mmHg)

Verbesserung von ptiO₂

($26,8 \pm 10,9$ zu $31,6 \pm 12,2$ torr: $p < 0,0001$)

Positiver Effekt der Hirnoxygenierung hebt
negativen Effekt der Hirndrucksteigerung auf

Does Prone Positioning Increase Intracranial Pressure? A Retrospective Analysis of Patients with Acute Brain Injury and Acute Respiratory Failure

Christian Roth · Andreas Ferbert · Wolfgang Deinsberger ·
Jens Kleffmann · Stefanie Kästner · Jana Godau ·
Marc Schüler · Michael Tryba · Markus Gehling

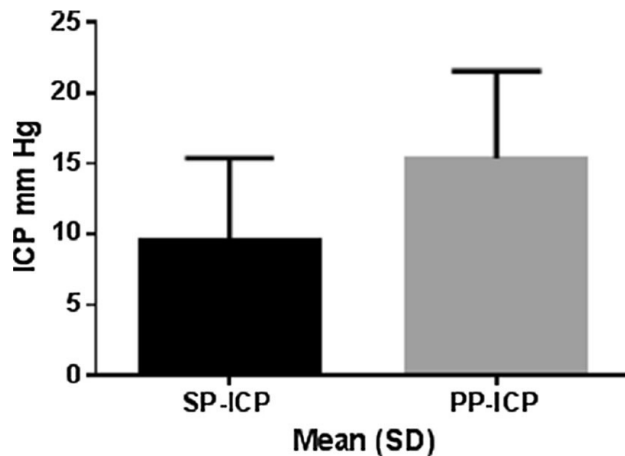


Fig. 1 Mean intracranial pressure (ICP) of 119 different episodes of prone positioning shows a significant increase compared to supine positioning

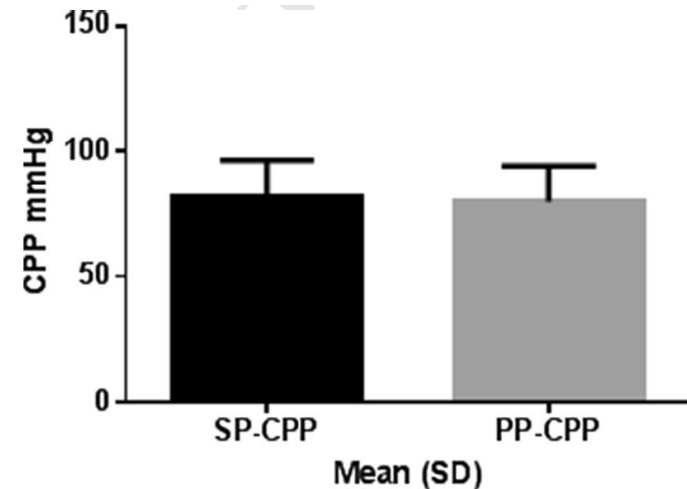


Fig. 2 Mean cerebral perfusion pressure (CPP) shows a mild, but non-significant decrease during prone positioning compared to supine positioning

Prone position - ICP

	Before	During	After	<i>p</i> value	Significance
PEEP (mbar)	11	11.1	10.6	0.1714	no
pCO ₂ (mmHg)	43.1	38.1	35.9	0.003	yes
PaO ₂ /FiO ₂ ratio	135.4	339.8	345.8	<0.0001	yes

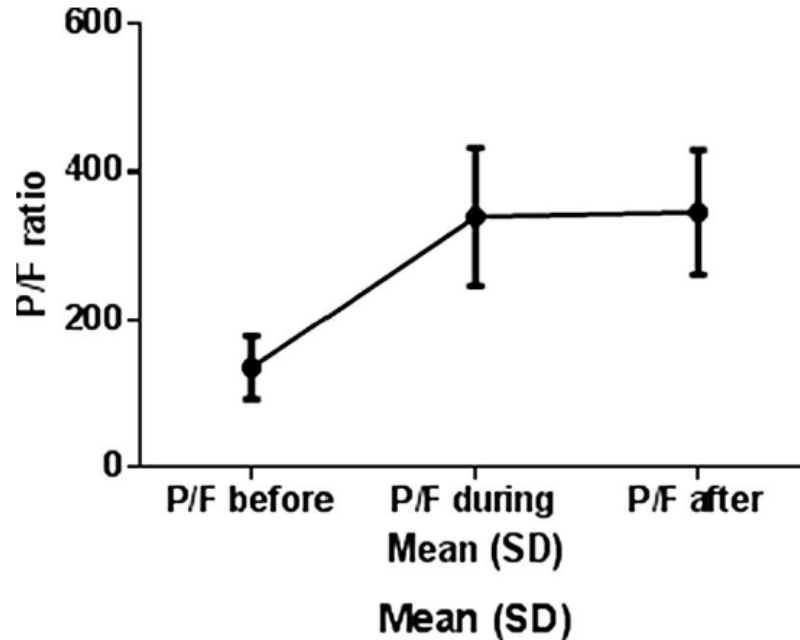
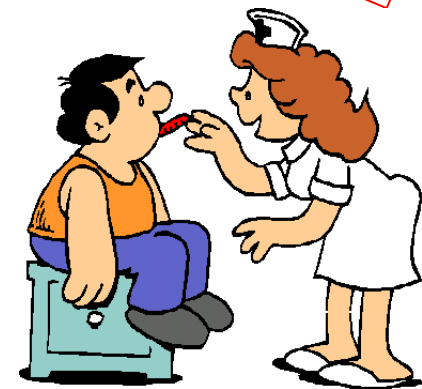


Fig. 3 P/F ratio before, during, and after termination of prone positioning

Verbesserte Oxygenierung!

ICP MESSEN!!



KLRT – kontinuierlich laterale Rotationstherapie



KLRT – kontinuierlich laterale Rotationstherapie



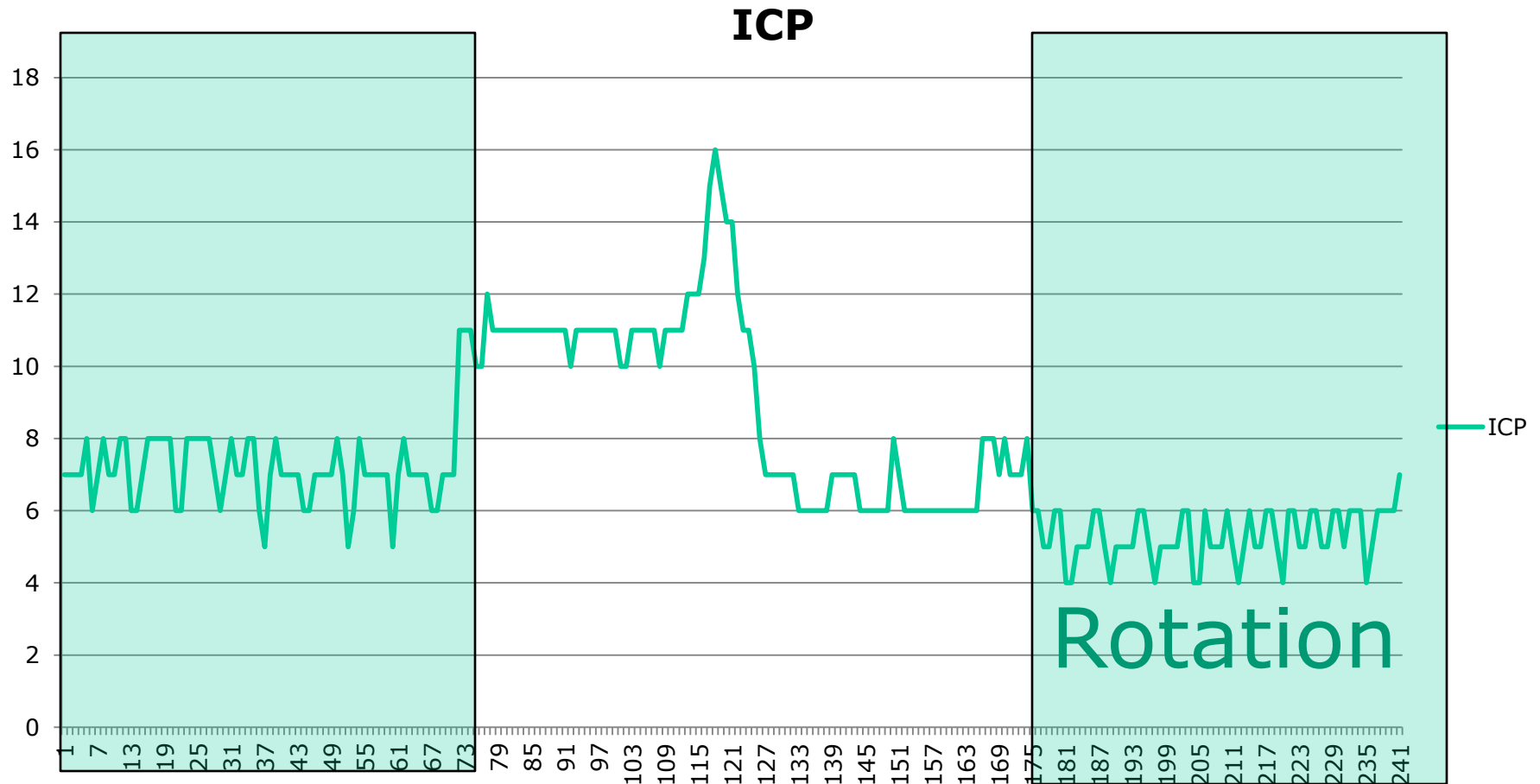
Positive Effekte

Outcomeverbesserung bisher nicht
nachgewiesen

(Outcomeverbesserung bei kardiogenem Schock)

Bein T. et al (1987) Intensive Care Med
Goldhill DR. et al. (2007) Am J Crit Care
Simon G. et al (2012) Clin Res Cardiol

KLRT – kontinuierlich laterale Rotationstherapie



KLRT – kontinuierlich laterale Rotationstherapie

10 komatöse Patienten mit ICP-Monitoring
Rotorest®-Bett

Rechts- und Linkslagerung vs. Rückenlage



Kein signifikanter Unterschied zwischen unterschiedlichen
Bettpositionen (rechts – mittig – links)

=> Rotorest Bett ist sicher anwendbar

TAKE HOME

- Alle Patienten 30° Oberkörperhochlagerung
- Achsengerechte Lagerung
- Keine Hyperventilation
- Invasive Maßnahmen führen zur transienten ICP Erhöhung
- Monitoring obligat! (Transporte, Tracheotomie, Lagerung)



Thank you for your attention!

Jens Kleffmann¹
Wolfgang Deinsberger¹
Andreas Ferbert²
Christian Roth²

*¹ Departement of Neurorsurgery
Klinikum Kassel*

² Departement of Neurology