



klinische Beurteilung sowie  
Monitoring von ICP und CPP:

überflüssig oder eine *conditio sine qua non*?

32. Fortbildungstagung der DGNC

Schädelhirntrauma

15. November 2013

Seeheim-Jugenheim



# Glasgow Coma Scale & Pupillenstatus

## Prä-Hospitalphase:

- + Schweregradeinteilung anhand GCS (leicht: 15-13, mittelschwer: 12-9, schwer: 8-3)
  - ⇒ Vorgehen vor Ort (z.B. Intubation)
  - ⇒ Rettungsmittel
  - ⇒ Wahl des Krankenhauses
  - ⇒ Info für das Aufnahmeteam
  - ⇒ Triage

## Hospitalphase:

- + klinische Kriterien einer neurologischen Verschlechterung („neuroworsening“)
  1. Abnahme im motor-GCS > 2
  2. neu auftretender Verlust der Pupillenreaktion
  3. neu auftretende Pupillenasymmetrie > 2mm
  4. neues fokal-motorisches Defizit
  5. Einklemmungssymptome

Pathophysiologie-ICP/ CPP

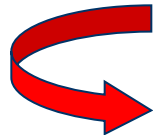
# zerebraler Sekundärschaden



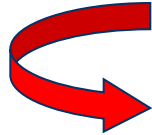
(Kontusion, Gefäßläsion)



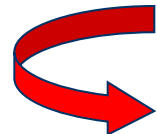
Sekundärschaden (z.B. Hypoxie, Hypotonie / Hämatom, Hirnödem)



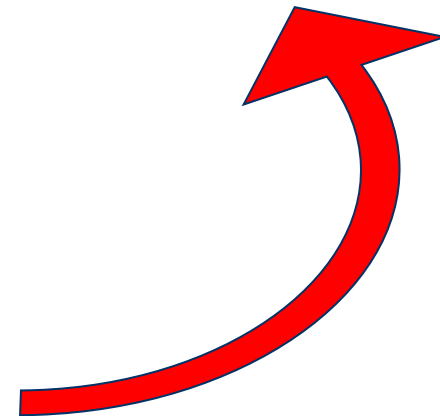
ICP $\uparrow$



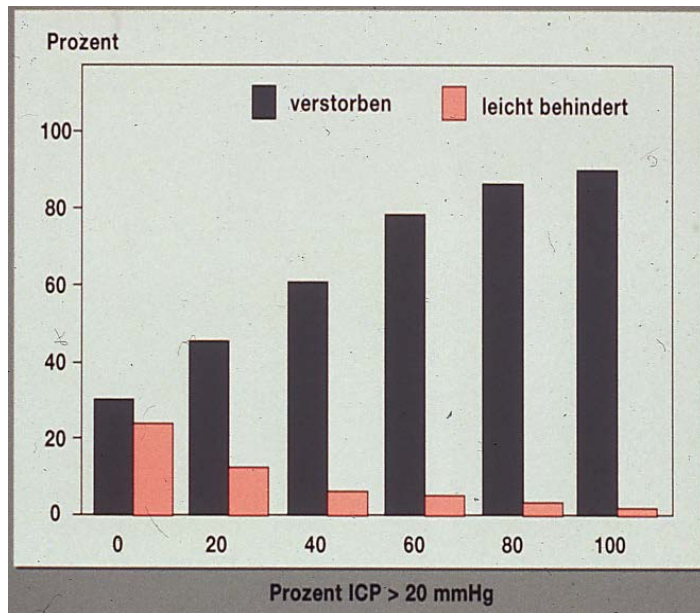
CCP $\downarrow$



Ischämie/Nekrose



## ICP | klinisch: alte & neue Daten



Marmarou, J Neurosurg, 1989

J Neurosurg 92:1-6, 2000

Intracranial hypertension and cerebral perfusion pressure: influence on neurological deterioration and outcome in severe head injury\*

NIELS JUUL, M.D., GABRIELLE F. MORRIS, M.D., SHARON B. MARSHALL, B.S.N.,  
THE EXECUTIVE COMMITTEE OF THE INTERNATIONAL SELFOTEL TRIAL,  
AND LAWRENCE F. MARSHALL, M.D.

Division of Neurological Surgery, University of California, San Diego, California; and Department of Neuroanesthesia and Neurointensive Care, Aalborg Hospital, Aalborg, Denmark

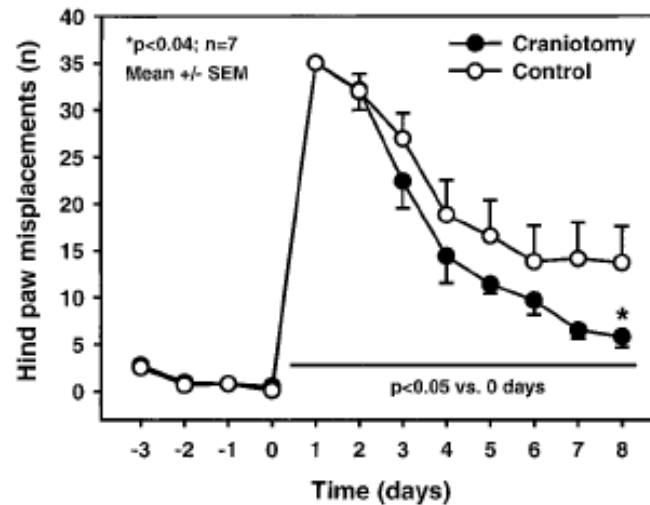
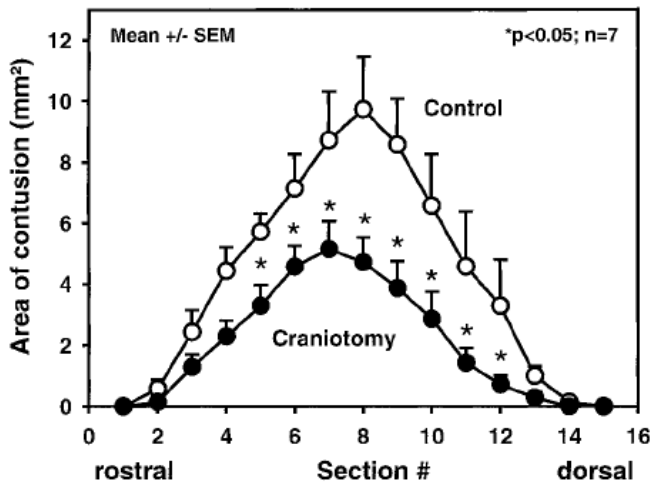
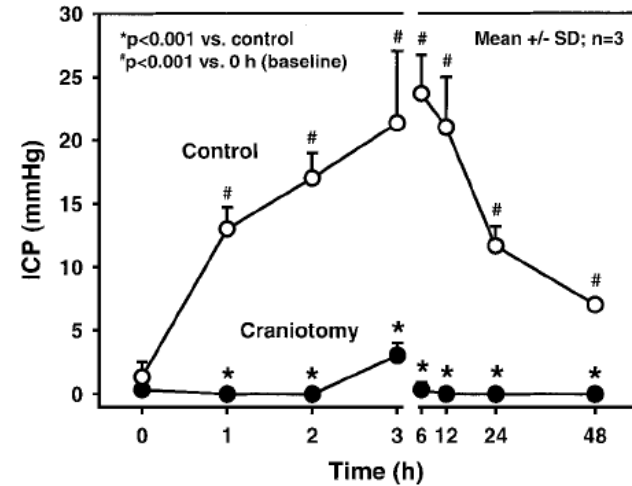
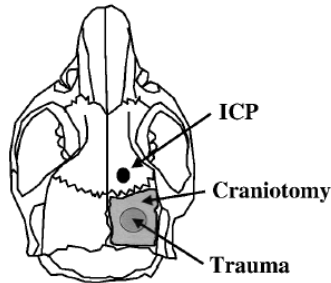
- n = 427, Phase III-Studie (Glutamatantagonist-Selfotel)
- ICP  $\geq$  20 mmHg stärkster Prädiktor einer neurologischen Verschlechterung

# ICP-Therapie

# experimentell

Zweckberger, J Neurotrauma, 2003

- Controlled Cortical Impact Injury, Ratte
- „Craniotomy“ (prim. Dekompressionskraniektomie)
- „Control“ (Verschluss des Kraniotomiedefekts)





ICP-Therapie

**klinisch** („ICP-monitoring improves outcome“)

BTF-Guidelines, 2007

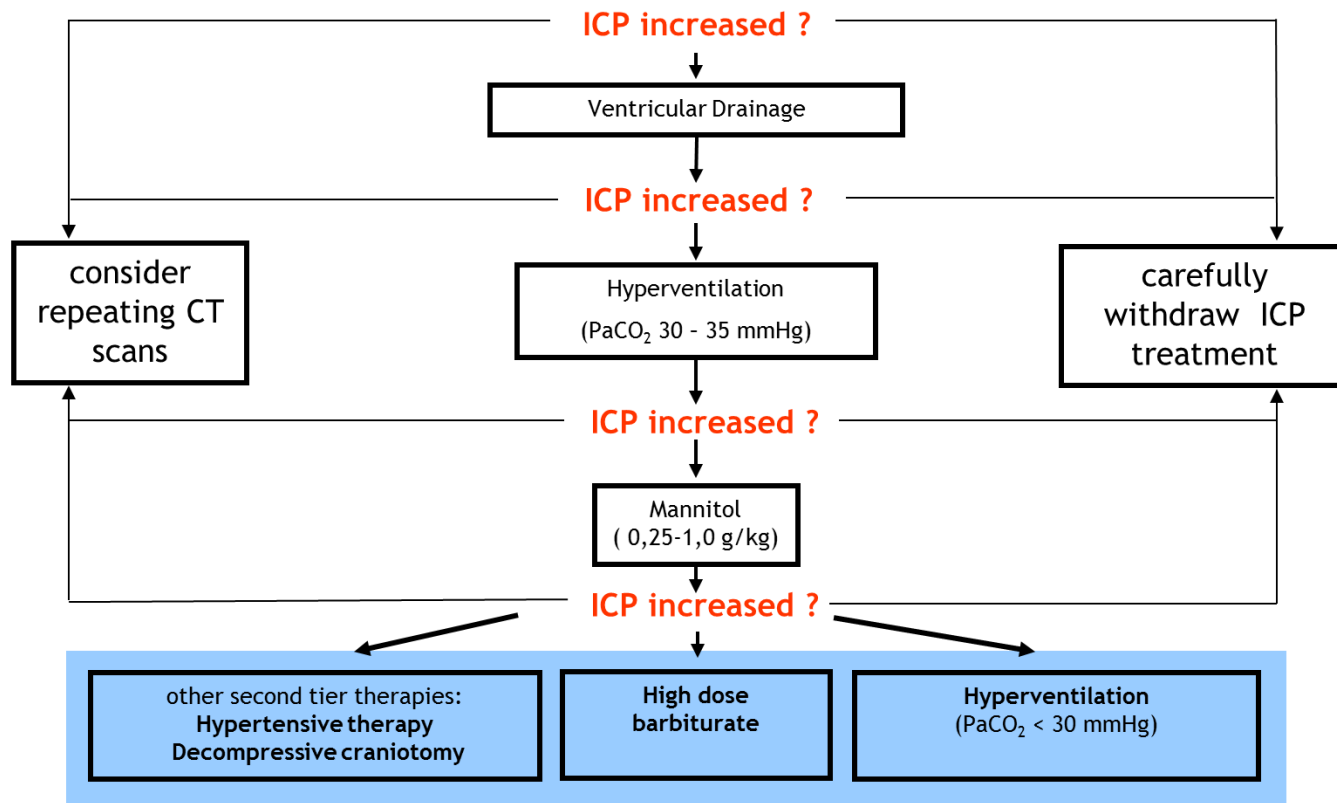
Reference	Data Class	Conclusion
Eisenberg et al., 1988 <sup>8</sup>	II	Because all decisions relative to therapy were based on ICP data, ICP monitoring was pertinent to therapy. Patients whose ICP could be controlled with pentobarbital had a much better outcome than those in whom it could not be controlled. At 1 month, 925 of the patients who responded to treatment survived and 83% who did not respond had died.
Saul et al., 1982 <sup>32</sup>	III	Mortality was 46% in the patients treated for ICP > 20/25 mm Hg and 28% in the 106 patients treated at an ICP level of >15 mm Hg.
Aarabi et al., 2006 <sup>1</sup>	III	Of the subgroup of 40 whose ICP had been measured before decompression, the mean ICP decreased after decompression from 23.9 to 14.4 mm Hg (p < 0.001). Of the 30-day survivors of the total original group of 50 (n = 39), 51.3% had a GOS score of 4 or 5.
Cremer et al., 2005 <sup>7</sup>	III	No significant difference in mortality or GOS at 12 months. Baseline differences between groups in hypotension on admission and number of patients transferred from other hospitals.
Fakhry et al., 2004 <sup>10</sup>	III	Significant decrease in mortality between patients from 1991-1996 and those from 1997-2000 (4.55, p = 0.047). Significantly more patients with GOS scores of 4 or 5 in the 1997-2000 cohort (61.5%) than in the 1995-1996 (50.3%) or 1991-1994 (43.3%) cohorts (p < 0.001).
Howells et al., 2005 <sup>12</sup>	III	Among the 64 patients treated with the CPP-oriented protocol, those with intact pressure autoregulation who responded to the CPP protocol by decreasing ICP had a significantly better outcome compared to those patients who responded by increasing ICP.
Lane et al., 2000 <sup>14</sup>	III	When severity of injury was controlled for, ICP monitoring was associated with improved survival.
Palmer et al., 2001 <sup>27</sup>	II	Mortality at 6 months was significantly reduced from 43 to 16% with the protocol. ICU days remained the same and hospital costs were increased. GOS scores of 4 or 5 increased from 27% in the pre-guidelines group to 69.6% in the post-guidelines group (odds ratio = 9.13, p = 0.005).
Patel et al., 2002 <sup>28</sup>	III	53 patients treated in the pre-establishment group had 59% ICP monitoring. 129 patients in the post-establishment group had 96% ICP monitoring. Significantly better outcomes were found in the post-establishment group.
Timofeev et al., 2006 <sup>36</sup>	III	Of 27 patients for whom pre- and post-surgical ICP was measured, mean ICP decreased from 25 ± 6 mm Hg to 16 ± 6 mm Hg (p < 0.01). Of the entire sample, 61.2% had a good recovery or moderate disability score on the GOS.



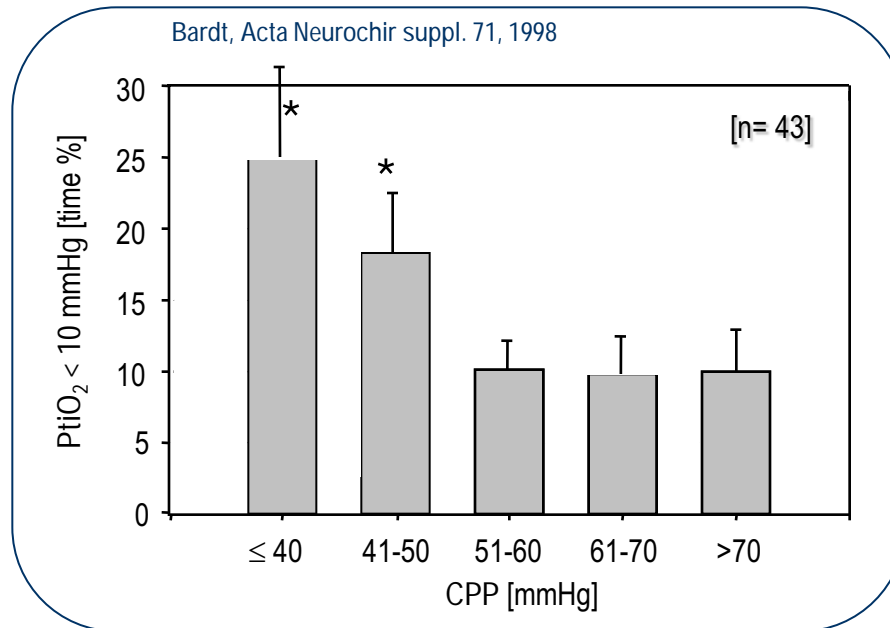
# ICP-Therapie

# klinischer Therapiealgorithmus

BTF-Guidelines 2000 & update 2003



## CPP | Surrogatparameter des CBF







CCP

“threshold”

Kristin, Neurosurgery, 2005

- Design: n = 81, schweres SHT, retrospektiv, MAP/ICP/ CPP

TABLE 3. Univariate regression of insult variables with favorable outcome as response variable<sup>a</sup>

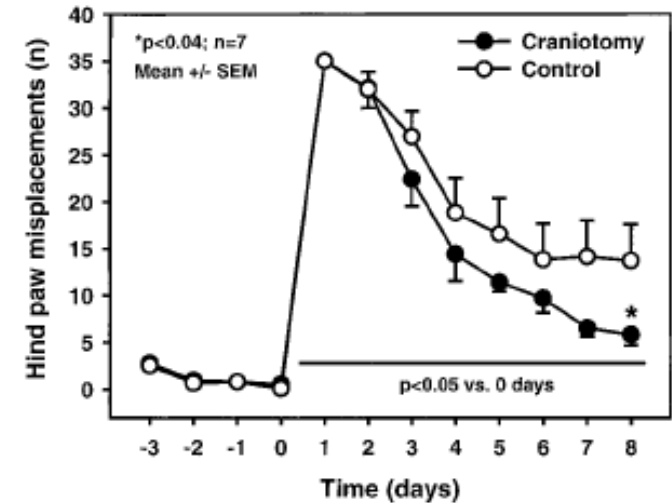
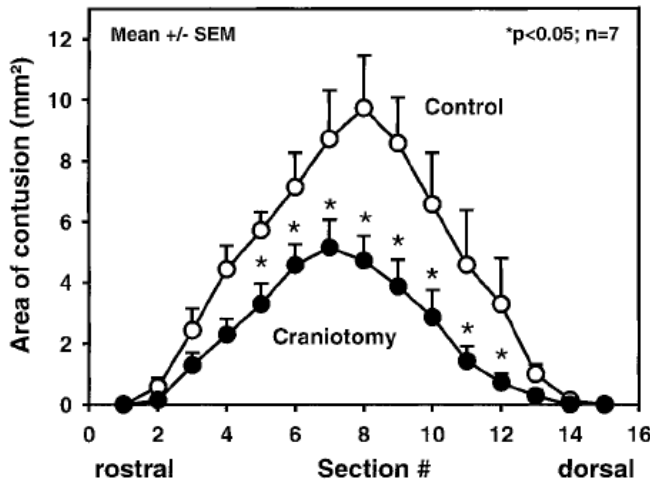
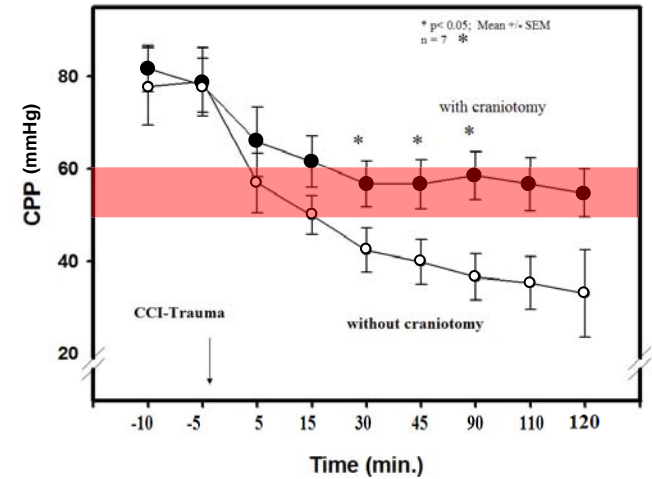
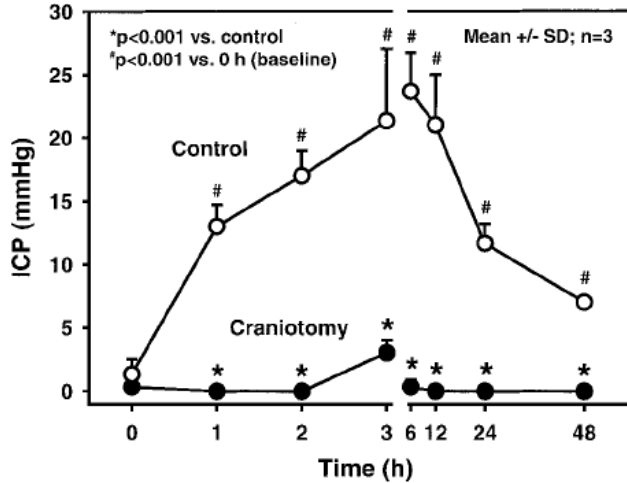
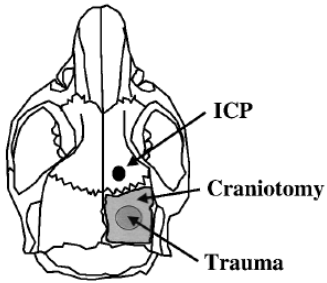
Insult variable (mm Hg)	OR	95% CI	<i>P</i>	Favorable outcome (mm Hg)
ICP >25			NS	
ICP >35			NS	
CPP <60	1.55	1.10–2.19	<0.05	More CPP <60
CPP <50			NS	
CPP >70	0.71	0.51–0.99	<0.05	Less CPP >70
CPP >80	0.69	0.49–0.98	<0.05	Less CPP >80

<sup>a</sup> OR, odds ratio; CI, confidence interval; ICP, intracranial pressure; BPs, systolic blood pressure; BPm, mean arterial pressure; CPP, cerebral perfusion pressure; NS, not significant. OR >1 increases probability of favorable outcome; OR <1 decreases probability of favorable outcome.

CCP

# "threshold" -experimentell

Zweckberger, J Neurotrauma, 2003





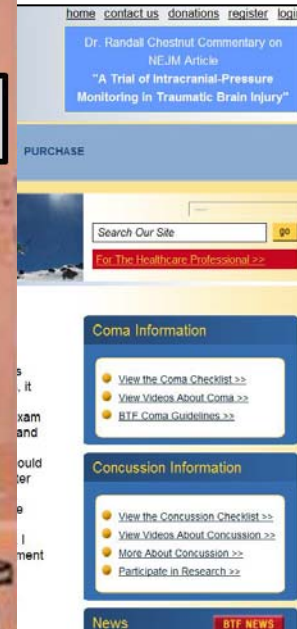
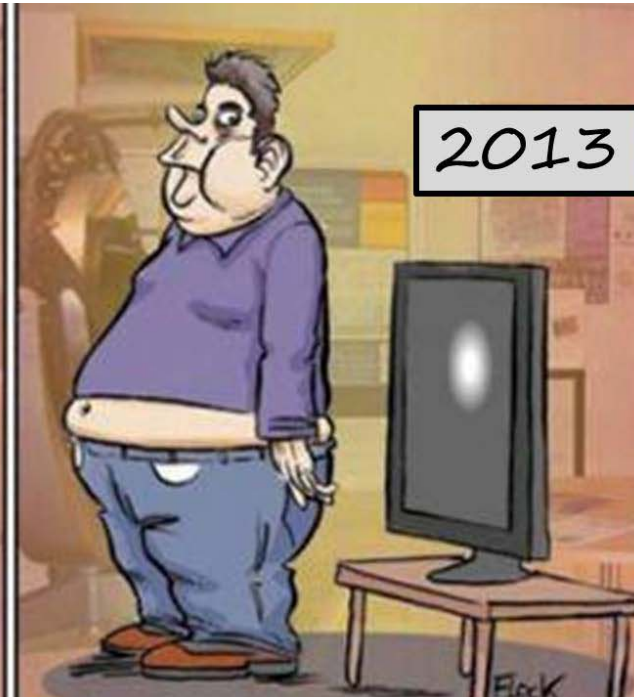
# ICP | aktueller Stellenwert?

## 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.





## ICP- vs. Imaging-Clinical Exam. (ICE)- guided therapy

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in Traumatic Brain Injury

### Settings:

- n = 324:                    n=157: ICP-Gruppe | n=167: ICE-Gruppe
- Einschlusskriterien: schweres SHT („non-penetrating“) GCS 3-8, Alter > 13 Jahre
- Design:                    multizentrisch -prospektiv-randomisiert
- Studienzentren:        Bolivien (4 x), Ecuador (2 x)
- ICP-Messung:            intraparenchymal (Camino®)
- ICP-Ziel:                 <20 mmHg
- Outcome-6 Mon.:
  - kumulative Überlebensrate (Kaplan-Meier)
  - GOS-E, Galveston Orientation Amnesia Test (GOAT), Disability Rating Scale (DRS)
  - Composite21: + GOS-E, Galveston Orientation Amnesia Test (GOAT), Disability Rating Scale (DRS), Mini Mental Stat Exam.  
+ Spanish Verbal Learning Test, Wechsler Adult Intelligence Scale III Digit Symbol & Search, Brief Visuospatial Memory Test, Grooved Pegboard Test, Color Trails, Controlled Oral Word Association Test (COWAT), Paced Auditory Serial Addition Test (PASA), etc.



## ICP- vs. imaging-clinical examination – guided therapy

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### Ergebnisse I:

**Table 2. Clinical Outcomes.\***

Variable	Pressure-Monitoring Group (N=157)	Imaging–Clinical Examination Group (N=167)	P Value	Proportional Odds Ratio (95% CI)†
Patients assessed at 6 mo — no. (%)	144 (92)	153 (92)		
Primary outcome‡: <b>Composite21</b>			0.49§	1.09 (0.74–1.58)
Median	56	53		
Interquartile range	22–77	21–76		
GOS-E scale at 6 mo — no. (%)				
Death	56 (39)	67 (44)**	0.40§	1.23 (0.77–1.96)
Unfavorable outcome	24 (17)	26 (17)		
Favorable outcome	63 (44)	60 (39)		



## ICP- vs. imaging-clinical examination – guided therapy

The NEW ENGLAND  
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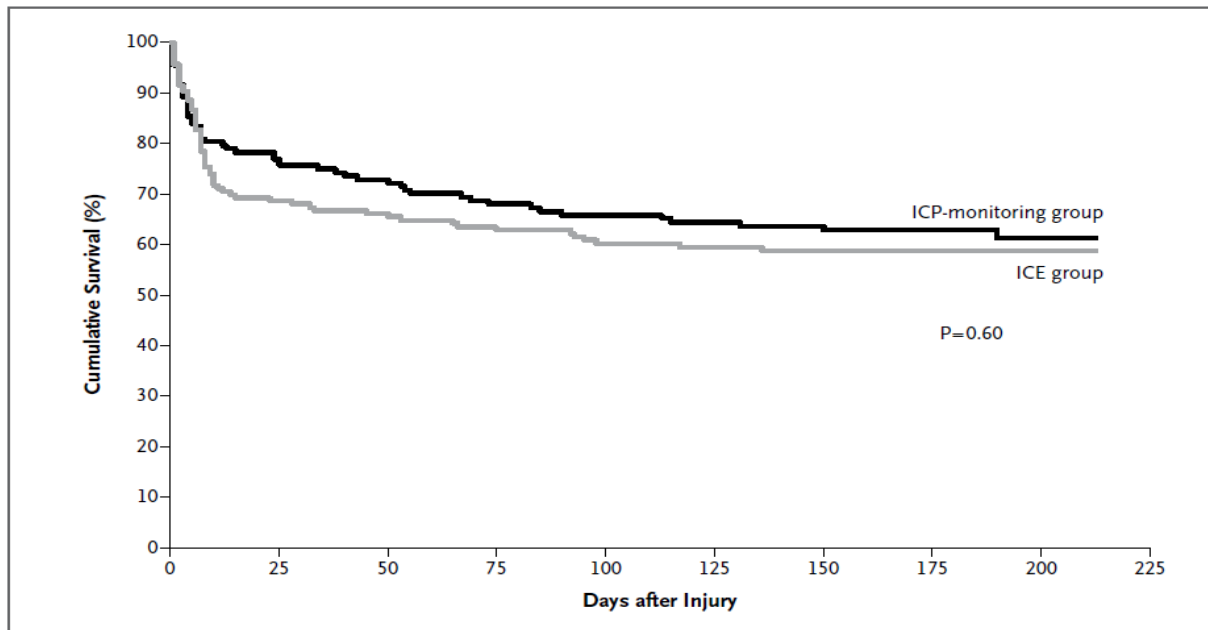
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### Ergebnisse II:



**Figure 1. Cumulative Survival Rate According to Study Group.**

A Kaplan–Meier survival plot based on the prespecified analysis shows the cumulative survival rate at 6 months among patients assigned to imaging and clinical examination (ICE) as compared with those assigned to intracranial-pressure (ICP) monitoring (hazard ratio for death, 1.10; 95% confidence interval [CI], 0.77 to 1.57). The inset shows the results of the post hoc analysis at 14 days (hazard ratio, 1.36; 95% CI, 0.87 to 2.11).



## ICP- vs. Imaging-Clinical Exam. (ICE)- guided therapy

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### Kritikpunkte:

- 45% Sekundärverlegungen zum Studienzentrum
- ICP-Therapie-unerfahrenes Team | ICE-Therapie-erfahrenes Team
- ICP-Monitoring zu kurz (Median: 3,6 Tage)
- antiödematöse Therapie in ICE-Gruppe länger (Median: 4,8 vs. 3,4)
- antiödematöse Therapie in ICE-Gruppe intensiver (Osmotherapie, Hyperventilation)
- „Integrated Brain-Specific Therapy Treatment Intensity“ in ICE-Gruppe intensiver ( $p < 0,001$ )
- keine Liquordrainage
- wenig Daten über CPP-MAP-Management
- Übergewicht neuropsychologischer Test bei Composite21
- GOS-E und kumulative Überlebensrate bei ICP-Gruppe um 5% besser, aber
- GOS-E „unterpower“ (324 Fälle; 40% Power um 10% besseres Outcome zu erfassen)



# ICP-CPP | aktueller Stellenwert?







ICP-CPP

es bleibt alles beim Alten !

BTF-Guidelines, 2007

## ICP

### Indikation zum Monitoring:

- ↪ Schweres SHT (GCS 3-8)...
- ... mit patholog. CT (Kontusion, Hämatom, Ödem, kompr. basale Zisternen)
- ...ohne patholog. CT: Alter >40 Jahre, unilat/bilat. Beugen/Strecken, syst. RR <90 mmHg (2 von 3)

### Therapie:

- ↪ Liquordrainage
- ↪ ICP < 20 mmHg (konservative & operative Therapie)

## CCP

- ↪ CPP > 70 mmHg vermeiden (ARDS-Gefahr!)
- ↪ CPP < 50 mmHg vermeiden (Ischämie-Gefahr!)
- ↪ CPP-Zielgröße 50-60 mmHg
- ↪ erweitertes zerebrales Monitoring erleichtert CPP-Management



Schweres SHT

## Monitoringparameter

1990

intrakranieller Druck (ICP)

zerebraler Perfusionsdruck (CPP)

jugular-venöse Oxymetrie (SjvO<sub>2</sub>)

Hirngewebe-PO<sub>2</sub> (PtiO<sub>2</sub>)

Nah-Infrarot Spektroskopie (NIRS)

Mikrodialyse (MD)

Howells et al., III  
2005<sup>12</sup>

Among the 64 patients treated with the CPP-oriented protocol, those with intact pressure autoregulation who responded to the CPP protocol by decreasing ICP had a significantly better outcome compared to those patients who responded by increasing ICP.

online Autoregulation (z.B. CPPopt mittels PRx)

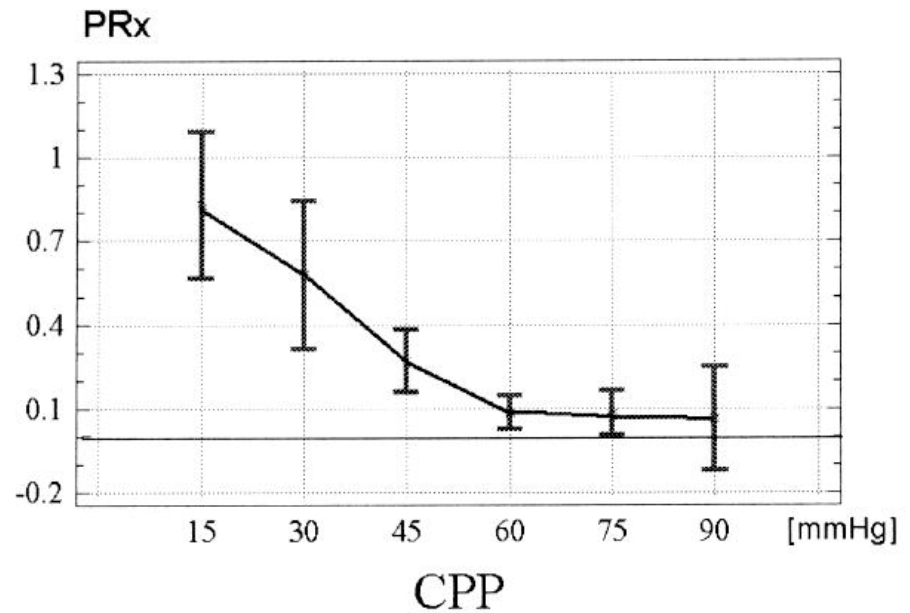
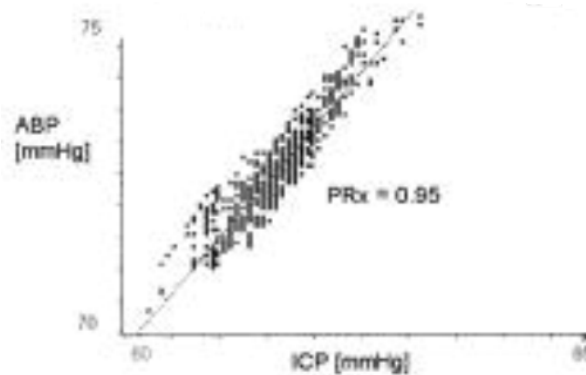
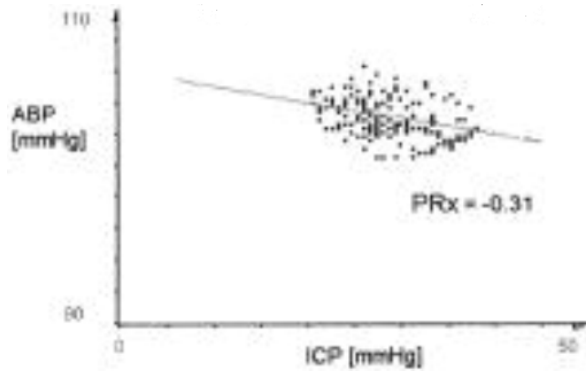
Elektro-kortiko-Gramm (EcoG)

2010



## CPP-Therapie

# optimaler CPP (PRx, Druckautoregulation) Czosnyka, Neurosurgery, 1997





## Zusammenfassung

- klinisch-neurologische Beurteilung
  - Klassifizierung (leichtes, mittelschweres, schweres SHT)
  - Steuerung des akut Managements
  - Verlaufsbeurteilung V.a. bei leichtem und mittelschwerem SHT („Neuroworsening“)
- zerebrales Monitoring
  - ICP | CPP | PtiO<sub>2</sub> | PRx
- „targeted therapy“
  - individuelle Anamnese/Pathologie | zeitlicher Verlauf (Klinik, Bildgebung, Monitoringparameter)