ICP monitoring u dětí

Milan Kratochvíl, KDAR FN Brno a MU

Initial ICP (torr)	Patient	GR/MD[a]		SD/VEG[b]		Dead	
	no.	no.	%	no.	%	no.	%
<20 A	38	14	37	17	45	7	18
20–40 A	13	10	76	0	0	3	24
>40 B	5	0	0	0	0	5	100

38%

Maximal ICP (torr)	Patient	GR/MD[a]		SD/VEG[b]		Dead	
	no.	no.	%	no.	%	no.	%
<20 A	28	16	57	10	36	2	7
20–40 A	14	8	57	6	43	0	0
>40 B	14	0	0	1	7	13	93

50%

Intensive Care Med (1988) 14:417–421

- Jestli monitorovat
- Jak monitorovat?
- Jaké informace jsem schopen získat?
- Jak léčit na základě ICP monitoringu?

- Jestli monitorovat
  - Kteří pacienti budou profitovat?
  - Jsou informace prospěšné?
  - Má ICP monitoring vliv na outcome?
- Jak monitorovat?
- Jaké informace jsem schopen získat?
- Jak léčit na základě ICP monitoringu?

A. Level I

There are insufficient data to support a level I recommendation for this topic.

B. Level II

There are insufficient data to support a level II recommendation for this topic.

C. Level III

Use of intracranial pressure (ICP) monitoring may be considered in infants and children with severe traumatic brain injury (TBI).

Pediatr Crit Care 2012, Vol. 13, No 1. (Suppl.)

Brain Trauma FOUNDATION

Guidelines for the Management of Severe Traumatic Brain Injury

4th Edition

- Intracranial pressure (ICP) should be monitored in all salvageable patients with a severe traumatic brain injury (TBI) (GCS 3-8 after resuscitation) and an abnormal computed tomography (CT) scan. An abnormal CT scan of the head is one that reveals hematomas, contusions, swelling, herniation, or compressed basal cisterns.
- ICP monitoring is indicated in patients with severe TBI with a normal CT scan if two or more of the following features are noted at admission: age over 40 years, unilateral or bilateral motor posturing, or systolic blood pressure (BP) <90 mm Hg.

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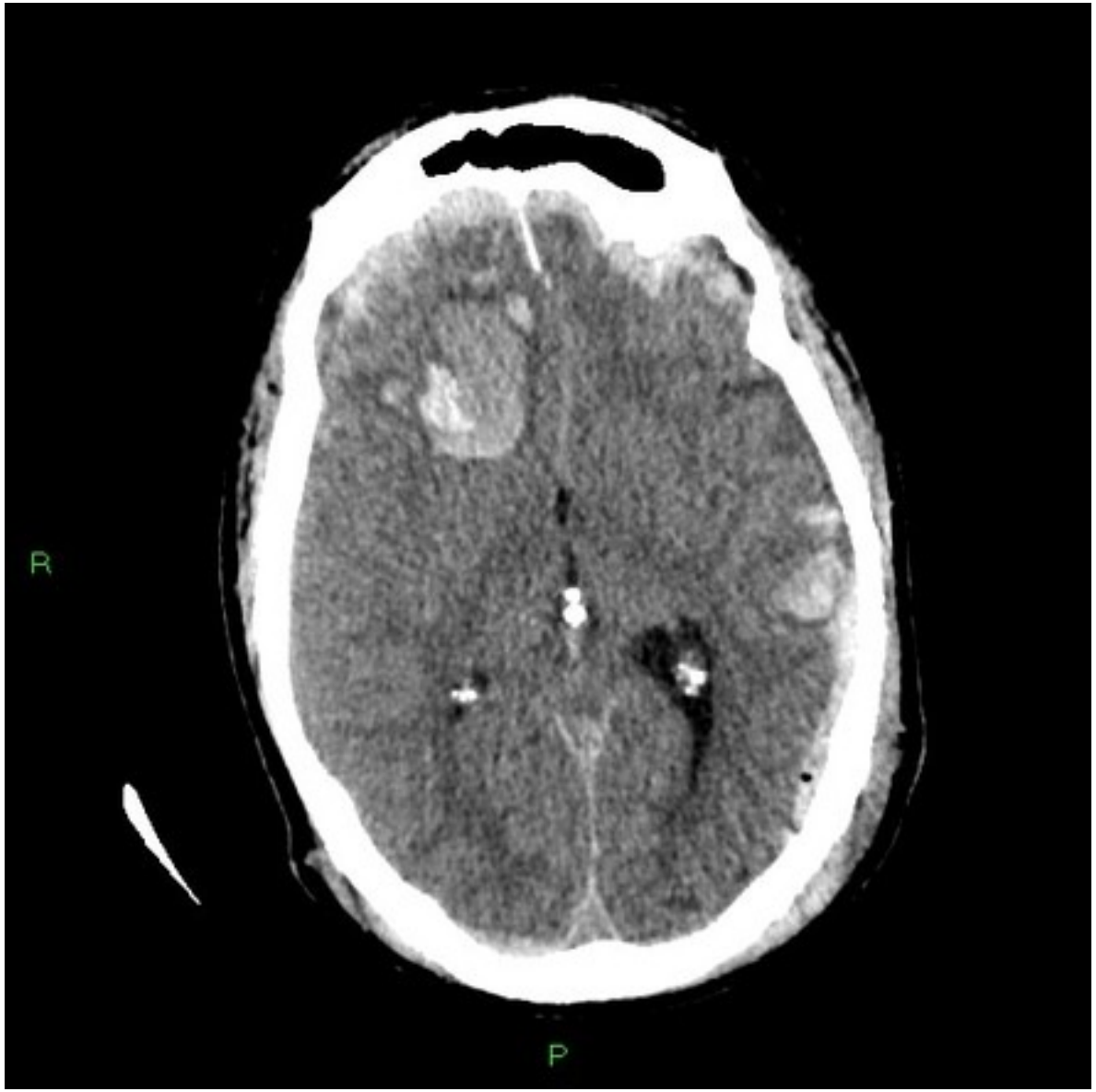
- Těžké mozkové trauma s abnormálním vstupním CT nálezem (hematom, SAK, kontuze, otok mozku, přesun středočáry, komprese bazálních cisteren, herniace).
- Těžké mozkové trauma s nemožností neurologické evaluace (potřeba dlouhodobé sedace).
- Potřeba extrakraniálních chirurgických výkonů u pacienta s těžkým mozkovým traumatem.
- U pacientů po evakuaci intrakraniálního hematomu:
  - S předoperačním GCS≤ 5 b.
  - Předoperační anizokorií, nebo bilaterální mydriázou.
  - Předoperační oběhovou nestabilitou.
  - Perioperačním nálezem mozkového edému.
  - Předoperačním rizikovým CT nálezem – přítomnosti dalších lézí, přesun středočáry >5 mm, zašlé bazální cisterny.
  - Nález nových intrakraniálních lézí, nebo progrese mozkového edému na kontrolním CT.
- Monitoring ICP není indikován v případě normálního vstupního CT nálezu, ani v případě CT nálezu podezřelého z difúzního axonálního poranění (DAP).


R
P

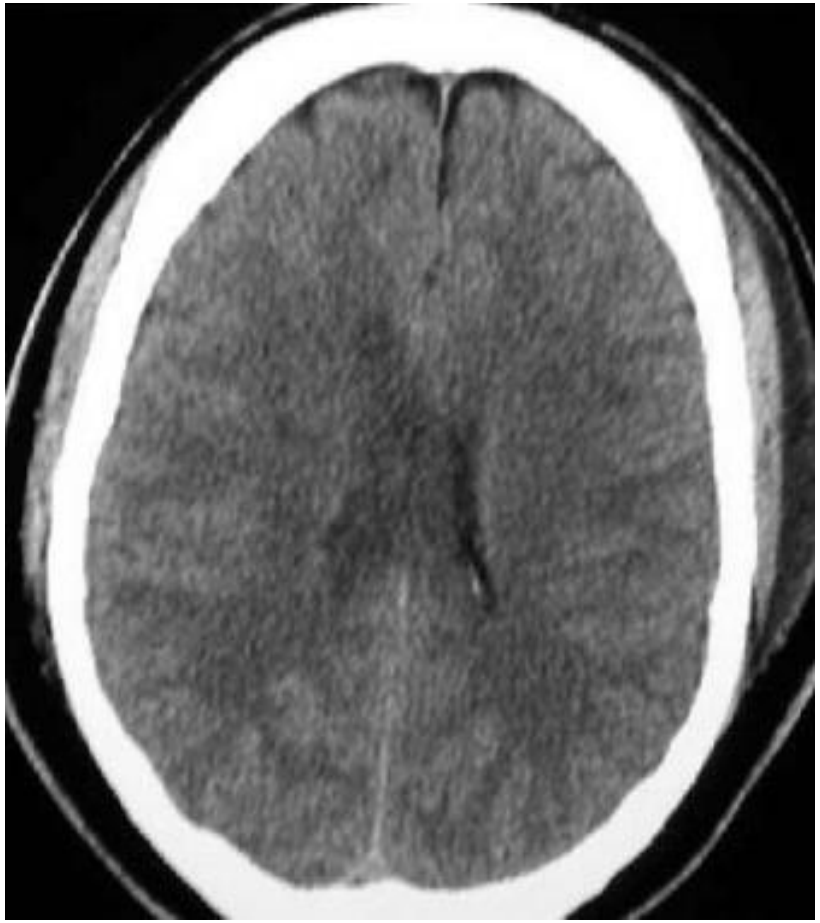


Table 3. Logistic Regression Model for Intracranial Pressure Monitoring Adjusted for Clustering by Hospital Using Generalized Estimating Equations

Feature	aOR (95% CI)
Age	
0 to 364 d	1 [Reference]
1 to <5 y	2.95 (2.38-3.66)
5 to <13 y	3.38 (2.72-4.21)
13 to <18 y	3.21 (2.50-4.13)

Arch Pediatr Adolesc Med. 2012;166(7):641-647

- Jestli monitorovat
  - Kteří pacienti budou profitovat?
  - Jsou informace prospěšné?
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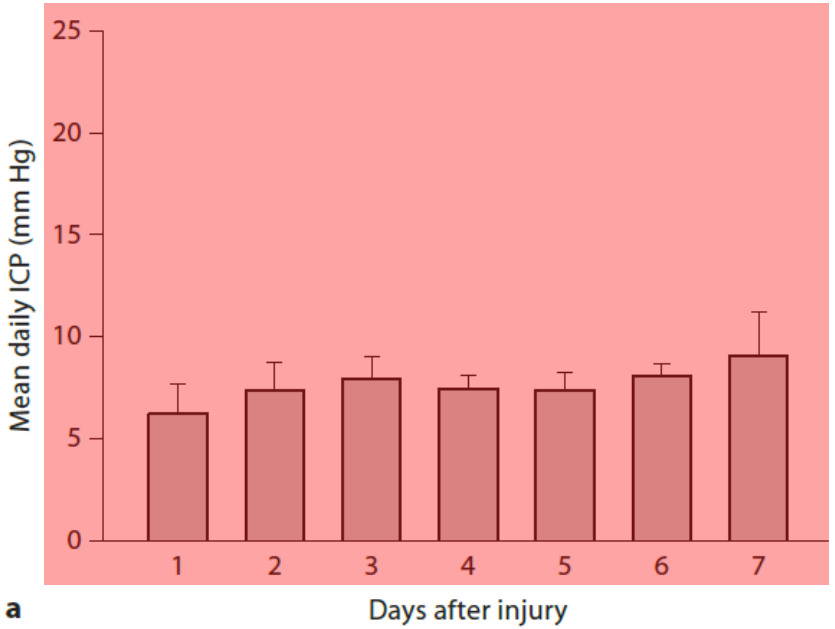
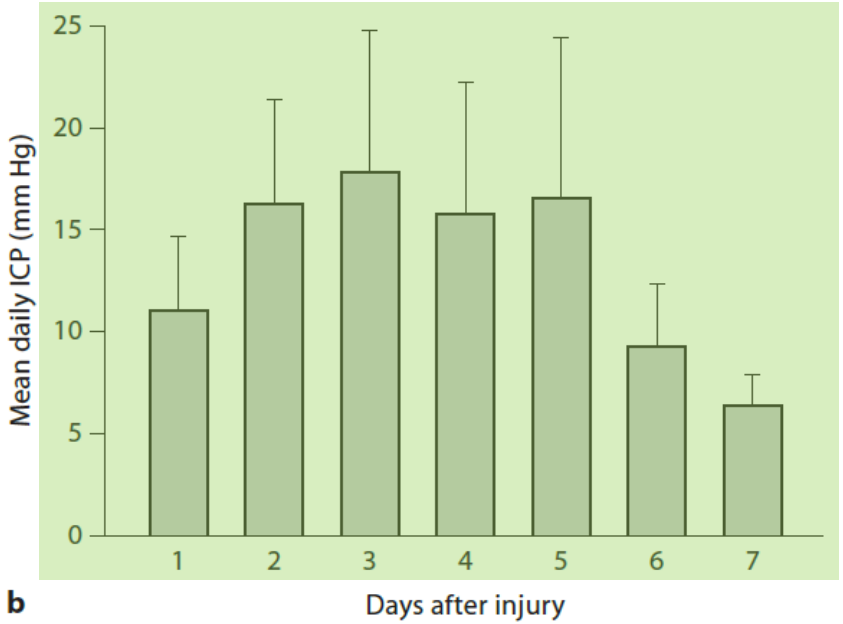
- Jak monitorovat?
- Jaké informace jsem schopen získat?
- Jak léčit na základě ICP monitoringu?





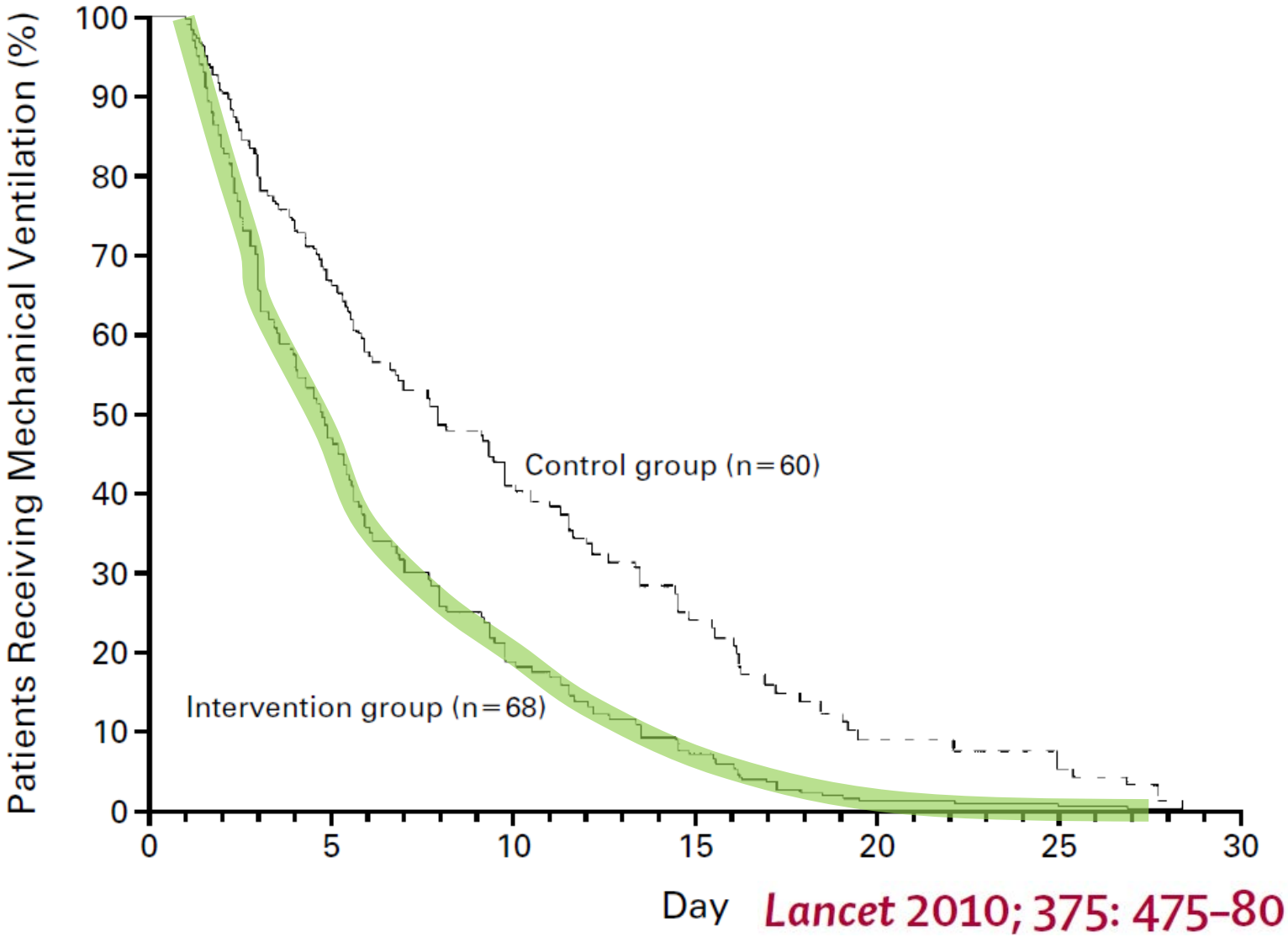
Dev Neurosci 2010;32:413–419

Table 4. Intracranial pressure (ICP) by survival status (mean ± SD)

Variable	Survivors	Nonsurvivors	*p* Value[a]
Highest recorded ICP (mm Hg)	26 ± 18	59 ± 33	.003
6-hr ICP (mm Hg)	19 ± 29	43 ± 27	.037
12-hr ICP (mm Hg)	18 ± 18	45 ± 27	.002
24-hr ICP (mm Hg)	16 ± 24	43 ± 34	.008

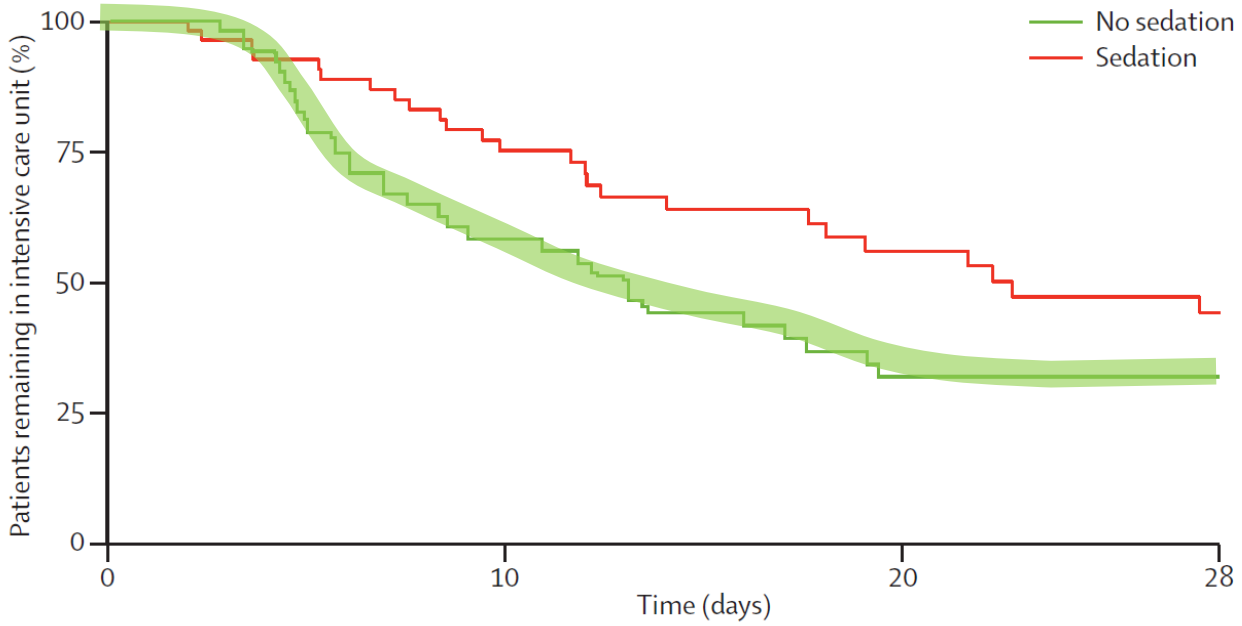
Crit Care Med 2001; 29:534 –540

Sedace



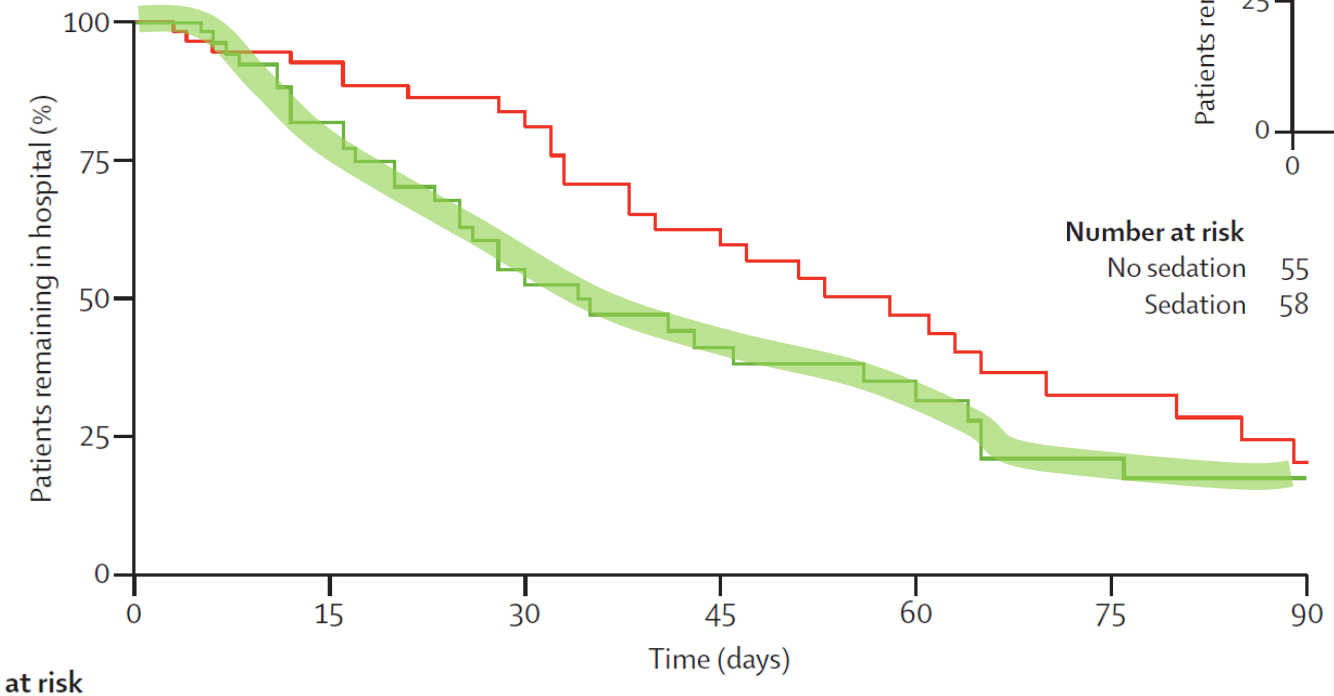
Lancet 2010; 375: 475–80

Sedace



Number at risk

No sedation	55	26	13	12
Sedation	58	38	20	15

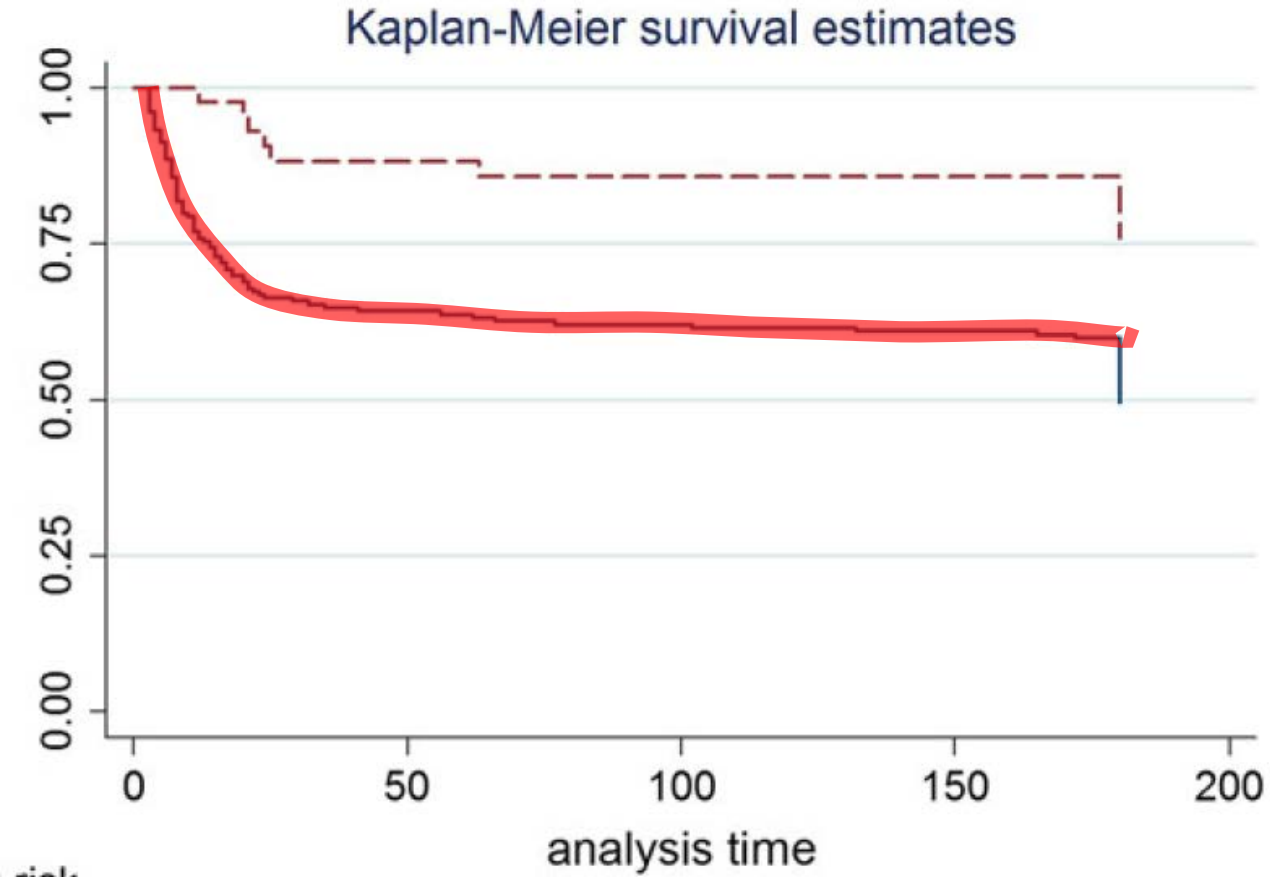


Number at risk

No sedation	55	35	21	14	10	6	4
Sedation	58	44	32	22	14	8	5

Thomas Strøm
Lancet 2010; 375: 475–80

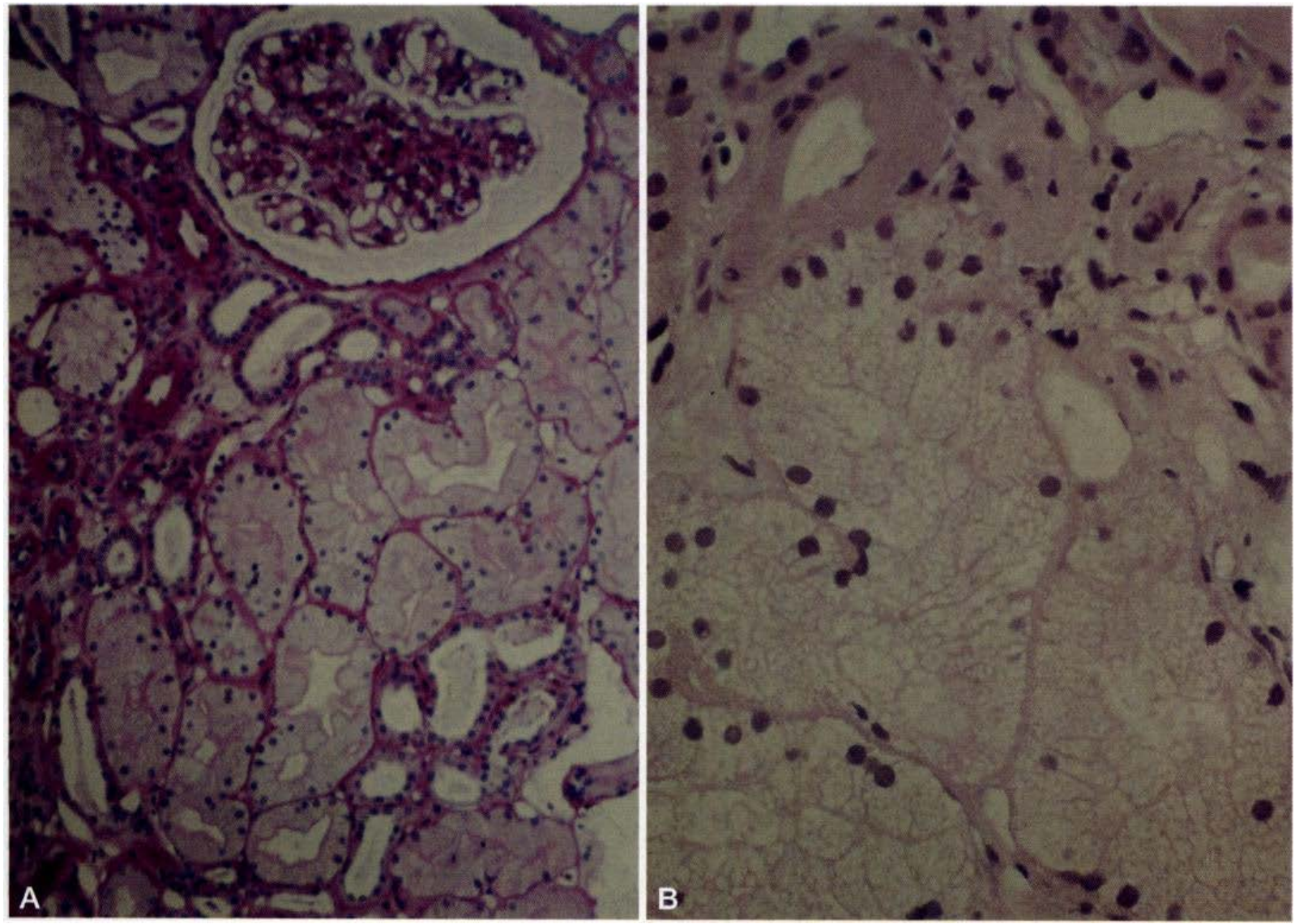
Sedace



Intensive Care Med (2013) 39:910–918

Mannitol-Induced Acute Renal Failure

PRIYA VISWESWARAN, EDWARD K. MASSIN, and THOMAS D. DUBOSE, JR.
Division of Renal Diseases and Hypertension, Department of Internal Medicine, University of Texas Medical School, Houston, Texas.



Barbituráty

Cochrane Library

Trusted evidence.
Informed decisions.
Better health.

Barbiturates for acute traumatic brain injury

0.62 to 1.06). In the other, mean ICP was also lower in the barbiturate group. Barbiturate therapy results in an increased occurrence of hypotension (RR 1.80; 95% CI 1.19 to 2.70). For every four patients treated, one developed clinically significant hypotension. Mean body temperature was significantly lower in the barbiturate group.

Cochrane 2012, 10.1002/14651858.CD000033.pub2

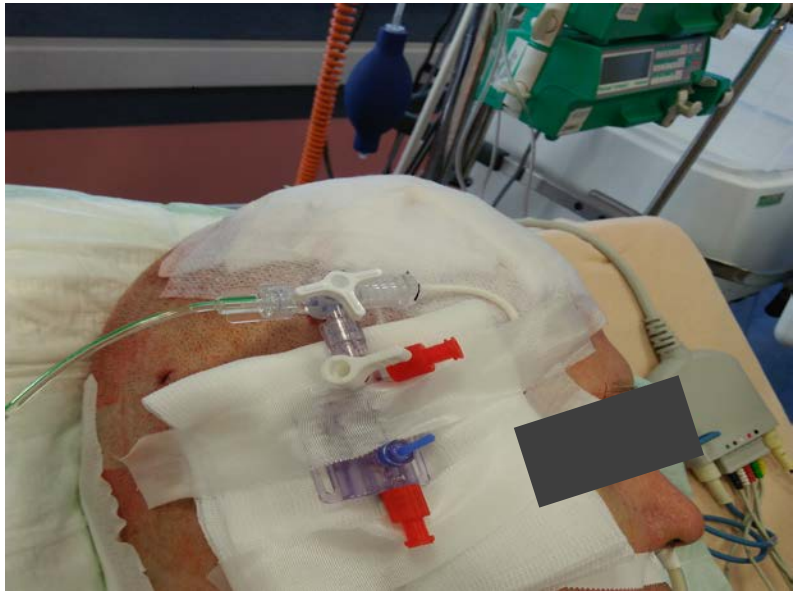
Table 3. (Continued.)

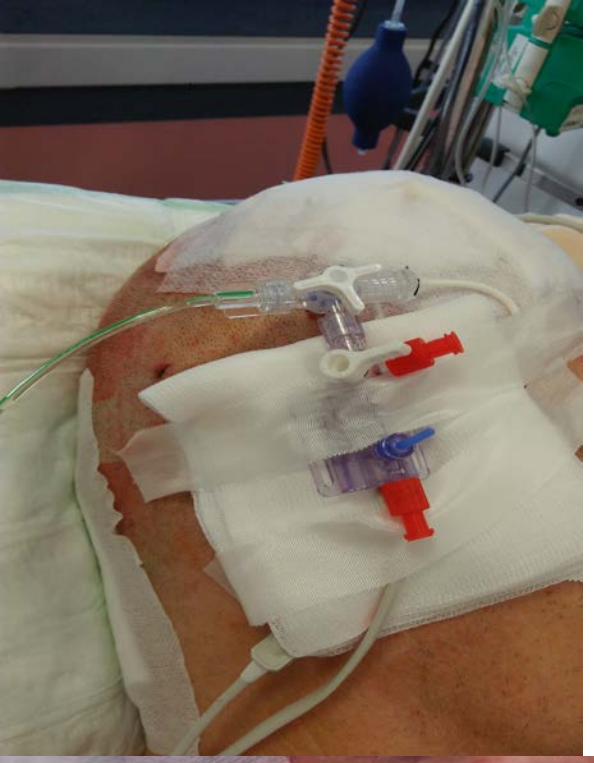
Variable	Pressure-Monitoring Group (N = 157)	Imaging–Clinical Examination Group (N = 167)	P Value†	Proportional Odds Ratio (95% CI)‡
Post hoc comparisons¶				
Integrated brain-specific treatment intensity			<0.001	2.36 (1.60–3.47)
Median	69	125		
Interquartile range	13–181	45–233		
Individual treatments — no./total no. (%)				
Mannitol	80/157 (51)	94/166 (57)	0.25	1.32 (0.82–2.13)
Hypertonic saline	90/156 (58)	119/166 (72)	0.008	1.95 (1.19–3.22)
Furosemide	6 (4)	13 (8)	0.11	2.53 (0.82–7.81)
Hyperventilation	93 (60)	122 (73)	0.003	2.16 (1.29–3.61)
Cerebrospinal fluid drainage	1 (1)	3 (2)	0.37	2.84 (0.29–27.78)
Barbiturates	38 (24)	22 (13)	0.02	0.46 (0.25–0.83)
Neurosurgical procedures — no./total no. (%)				
Craniotomy for mass lesion	63/157 (40)	74/166 (45)	0.50	1.19 (0.76–1.86)
Craniectomy	44/157 (28)	49/166 (30)	0.81	1.04 (0.63–1.69)
Alone	9 (6)	9 (5)	1.00	0.93 (0.35–2.42)
With other neurosurgical procedure	35 (22)	40 (24)	0.79	1.07 (0.63–1.80)

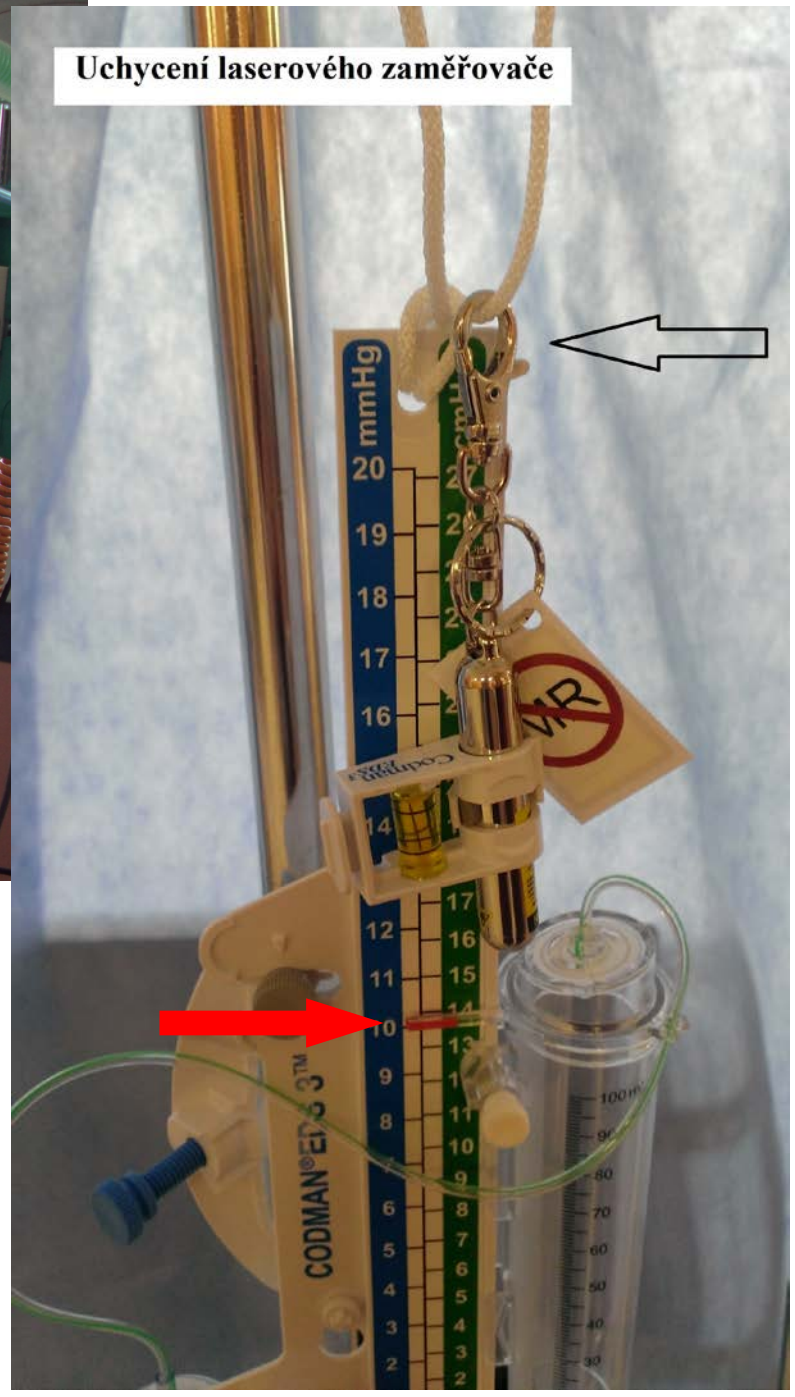
N Engl J Med 2012;367:2471-81.

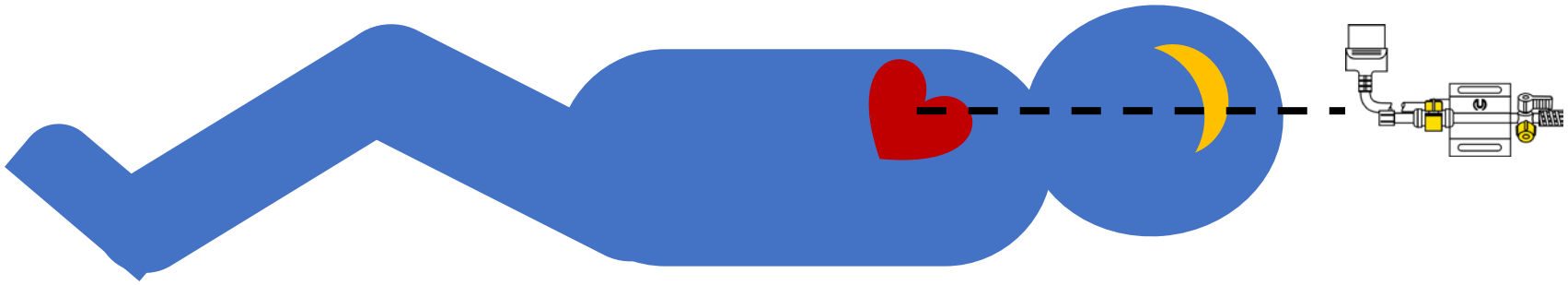
- Rozhodnout, jestli monitorovat
- Jak monitorovat?
- Jaké informace jsem schopen získat?
- Jak léčit na základě ICP monitoringu?

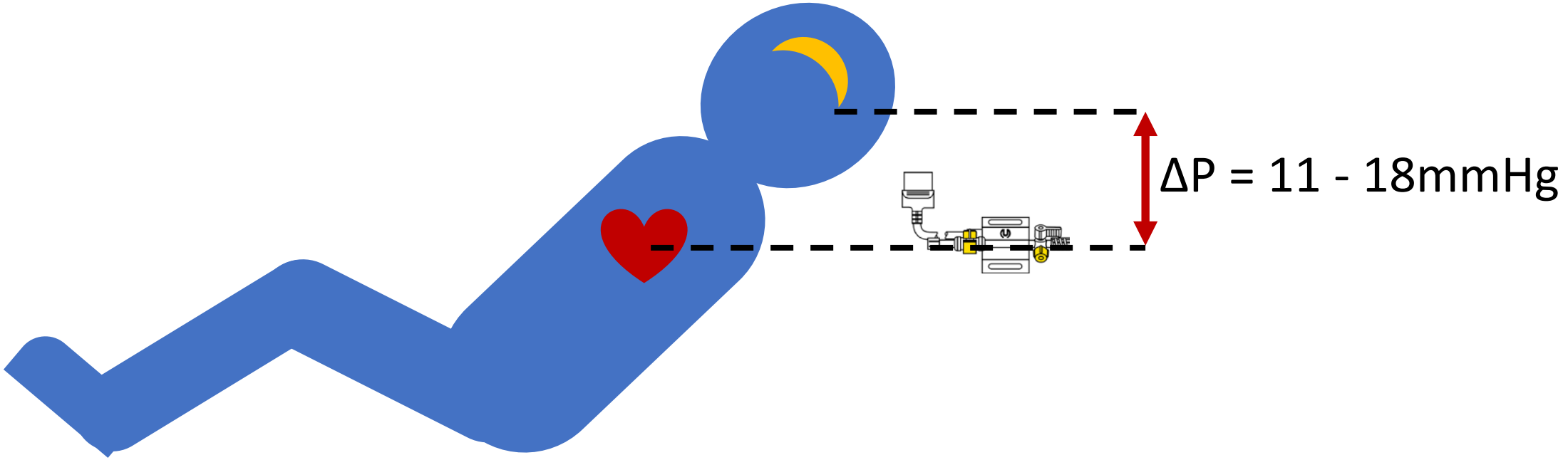

Codman
ICP Express
Codman






Uchycení laserového zaměřovače
mmHg
CODMAN® ICP 3™




ΔP = 11 - 18mmHg

- Rozhodnout, jestli monitorovat
- Jak monitorovat?
- Jaké informace jsem schopen získat?
- Jak léčit na základě ICP monitoringu?


Codman
ICP
12
mmHg
SYS: 14
DIAS: 9
MENU
0
20
100
ICP

I. RECOMMENDATIONS

Strength of Recommendation: Weak.
Quality of Evidence: Low, from poor-quality class III studies.

A. Level I

There are insufficient data to support a level I recommendation for this topic.

B. Level II

There are insufficient data to support a level II recommendation for this topic.

C. Level III

Treatment of intracranial pressure (ICP) may be considered at a threshold of 20 mm Hg.

Pediatr Crit Care 2012, Vol. 13, No 1. (Suppl.)

JOURNAL OF NEUROTRAUMA
Volume 24, Supplement 1, 2007

Pp. S-59–S-64
DOI: 10.1089/neu.2007.9987

Guidelines for the Management of Severe Traumatic Brain Injury

3rd Edition

B. Level II

Treatment should be initiated with intracranial pressure (ICP) thresholds above 20 mm Hg.

KDAR
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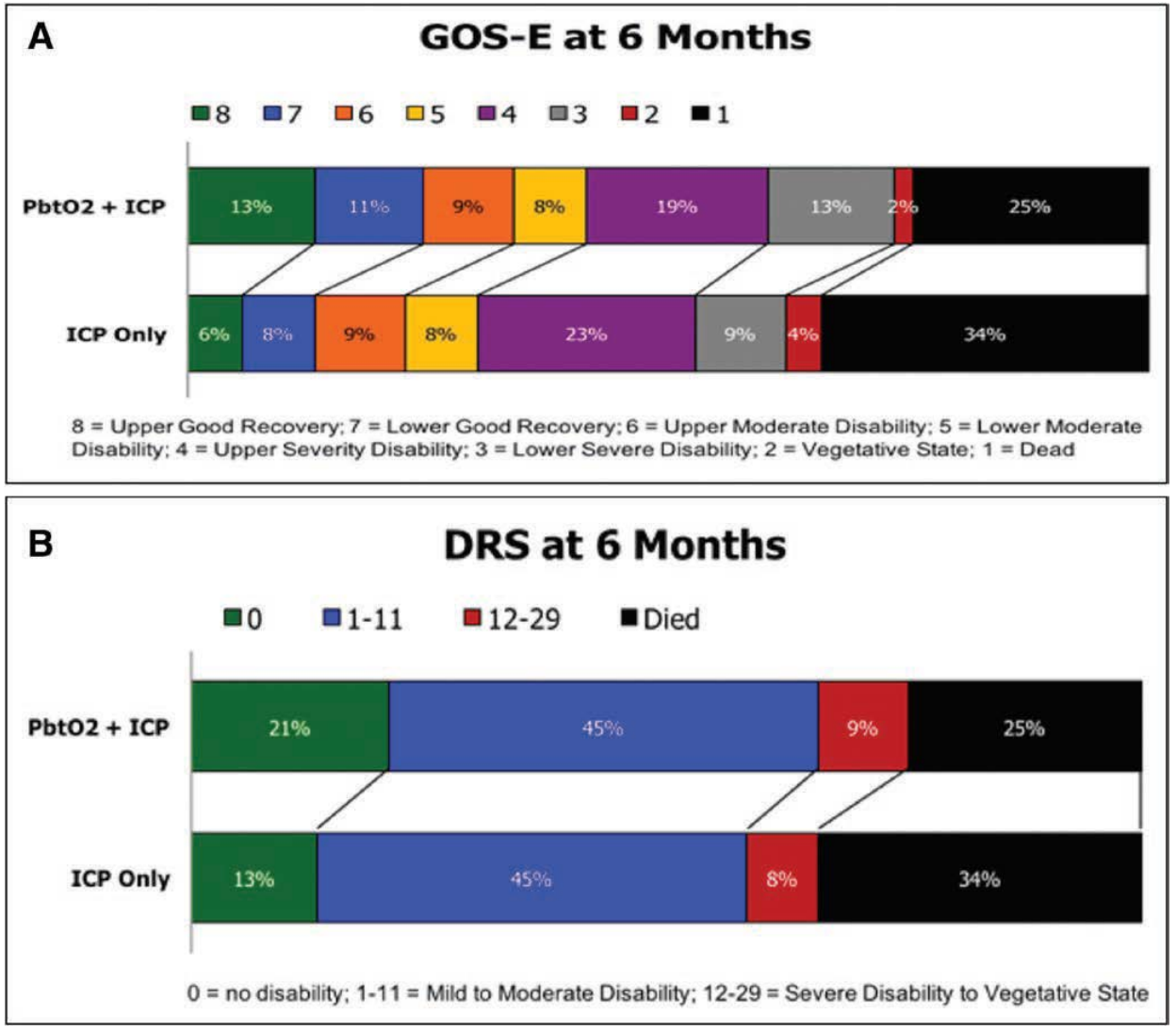
- Kritériem pro zahájení léčby nitrolební hypertenze u pacientů s TBI je elevace ICP>20 mmHg po dobu delší, než 5 minut. Cílem terapie je udržení ICP v hodnotách <= 20 mmHg.
- V případě obtížné kontroly ICP je přípustné udržovat ICP v hodnotách <25 mmHg, pokud je dosaženo dostatečného CPP.

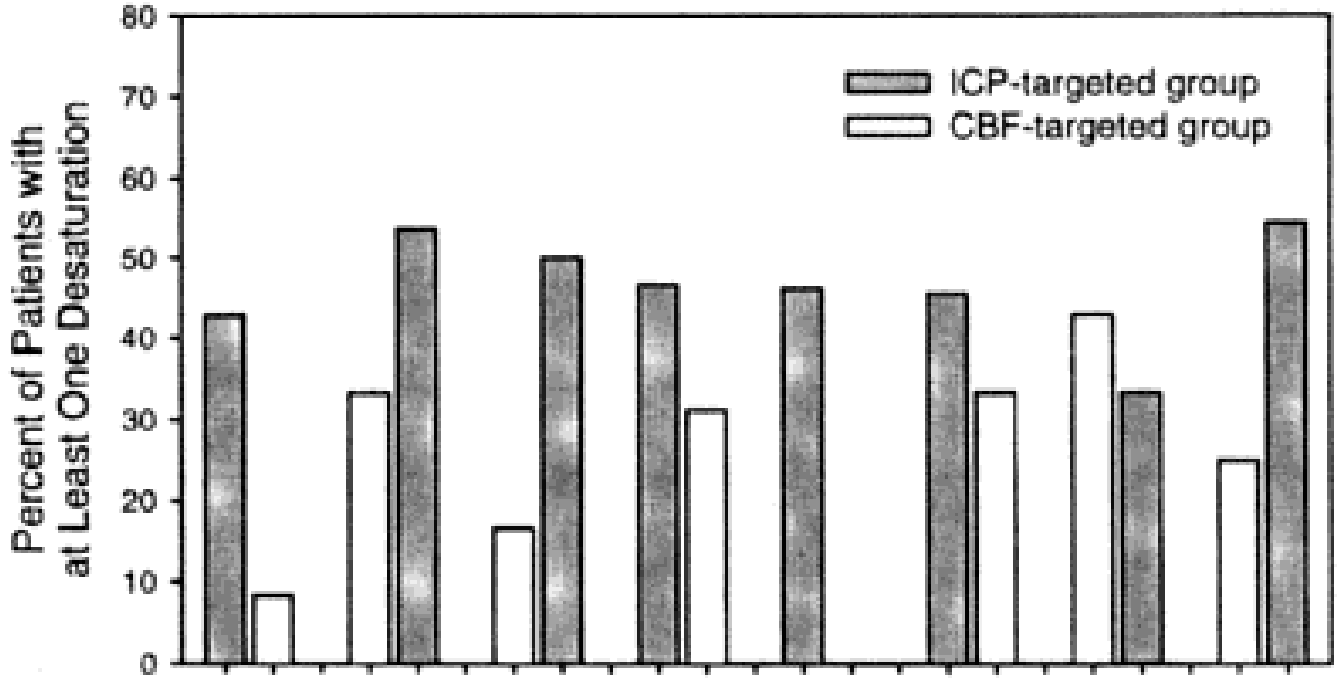

L5
2-čvn 10:38
Všech/Alar/Vypn 0:58
Vyp. stimulátor
Dospělý
HR
82
ART
151
ICP
9
CPP
74
PLS
82
Ta
36.9
RESP
17
EKG

CPP = MAP - ICP

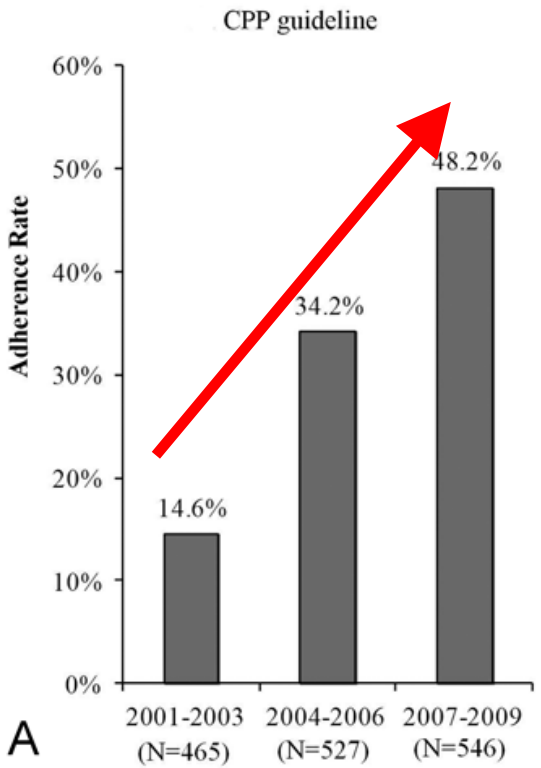
Mozková oxygenace a outcome

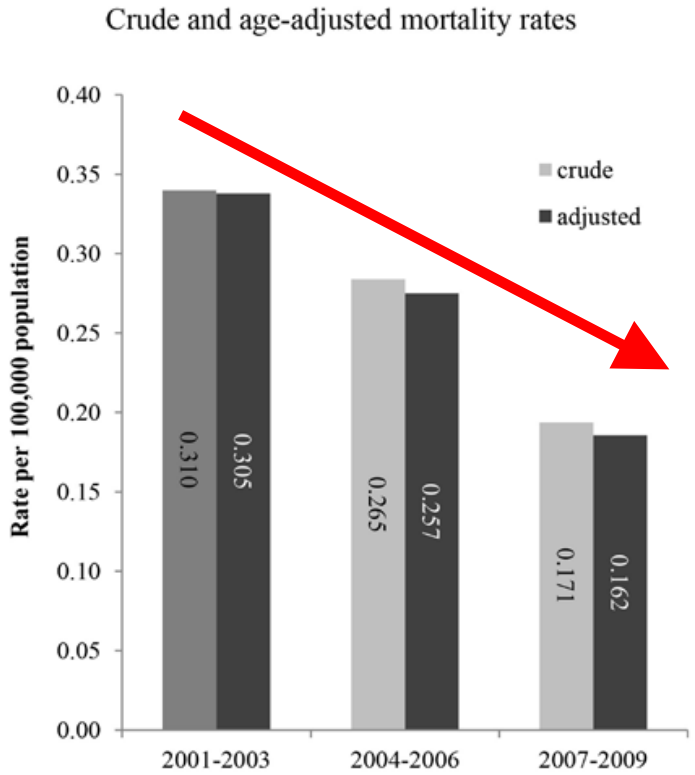


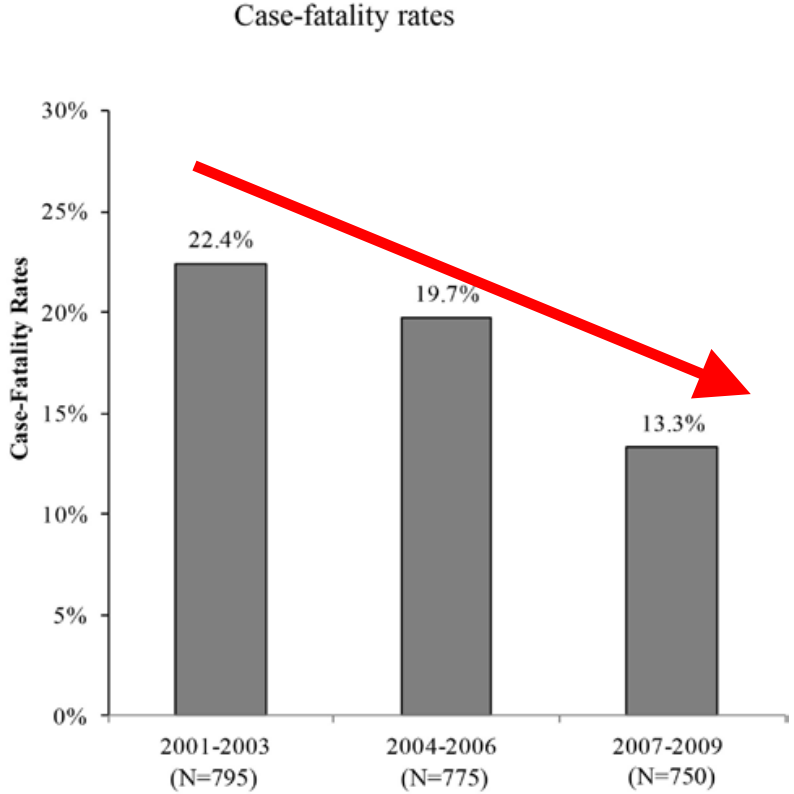
Crit Care Med 2017; 45:1907–1914



Critical Care Medicine
Issue: Volume 27(10), October 1999, pp 2086-2095







J Neurosurg / Volume 119 / December 2013

Neurocritical Care

ISSN 1541-6933/06/4:8–13
DOI: 10.1385/Neurocrit. Care 2006;04:8–13

Original Article

Impact of Intracranial Pressure and Cerebral Perfusion Pressure on Severe Disability and Mortality After Head Injury

Marcella Balestreri,[1,2] Marek Czosnyka,[1] Peter Hutchinson,[1] Luzius A. Steiner,[1,3] Magda Hiler,[1] Piotr Smielewski,[1] and John D. Pickard[1]*

[1]Academic Neurosurgical Unit Addenbrooke's Hospital, Cambridge, UK; [2]Policlinico San Matteo, University of Pavia, Italy; [3]Department of Anaesthesia, University Hospital Basel, Switzerland

Results: The mortality rate was greater in those having mean ICP greater than 20 mmHg (17% below versus 47% above; $p < 0.0001$). The mortality rate was dramatically increased for CPP below 55 mmHg (81% below versus 23% above; $p < 0.0001$). For values of CPP greater than 95 mmHg, favorable outcome was less frequent (50% below versus 28% above; $p < 0.033$). The rate of severe disability showed the tendency to increase with CPP ($r = 0.87$; $p = 0.02$), suggesting that a higher CPP does not help in achieving favorable outcomes.

JOURNAL OF NEUROTRAUMA
Volume 24, Supplement 1, 2007

Pp. S-59–S-64
DOI: 10.1089/neu.2007.9987

Guidelines for the Management of Severe Traumatic Brain Injury

3rd Edition

C. Level III

CPP of <50 mm Hg should be avoided.

The CPP value to target lies within the range of 50–70 mm Hg. Patients with intact pressure autoregulation tolerate higher CPP values.

Ancillary monitoring of cerebral parameters that include blood flow, oxygenation, or metabolism facilitates CPP management.

Brain Trauma FOUNDATION

Guidelines for the Management of Severe Traumatic Brain Injury
4th Edition

RECOMMENDATIONS

Level I and II A

- There was insufficient evidence to support a Level I or II A recommendation for this topic.

Level II B

- The recommended target cerebral perfusion pressure (CPP) value for survival and favorable outcomes is between 60 and 70 mm Hg. Whether 60 or 70 mm Hg is the minimum optimal CPP threshold is unclear and may depend upon the patient's autoregulatory status.

I. RECOMMENDATIONS

Strength of Recommendations: Weak.
Quality of Evidence: Low, from poor- and moderate-quality class III studies.

A. Level I

There are insufficient data to support a level I recommendation for this topic.

B. Level II

There are insufficient data to support a level II recommendation for this topic.

C. Level III

A minimum cerebral perfusion pressure (CPP) of 40 mm Hg may be considered in children with traumatic brain injury (TBI).

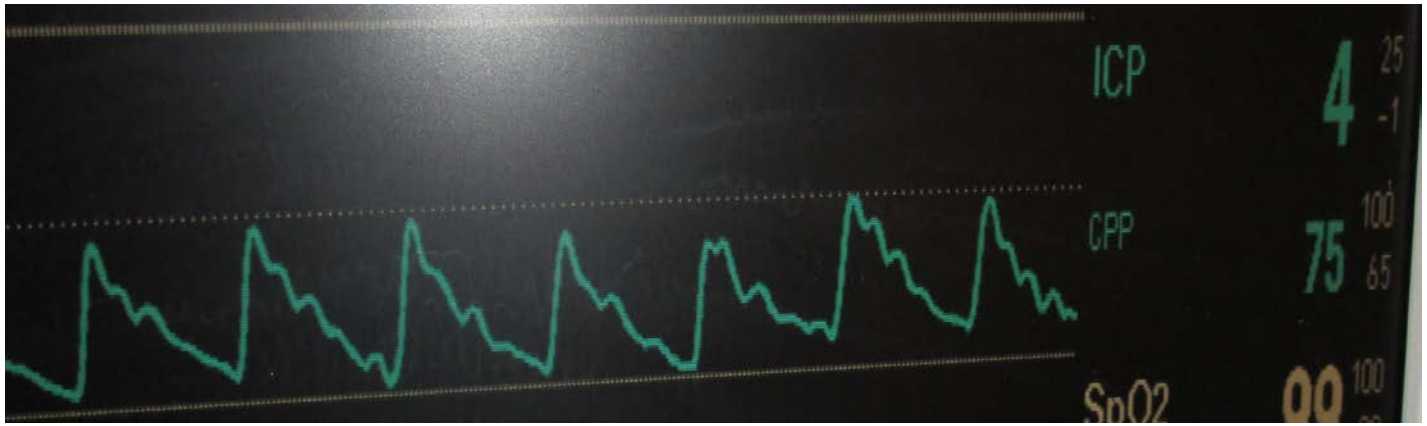
A CPP threshold 40–50 mm Hg may be considered. There may be age-specific thresholds with infants at the lower end and adolescents at the upper end of this range.

Pediatr Crit Care 2012, Vol. 13, No 1. (Suppl.)

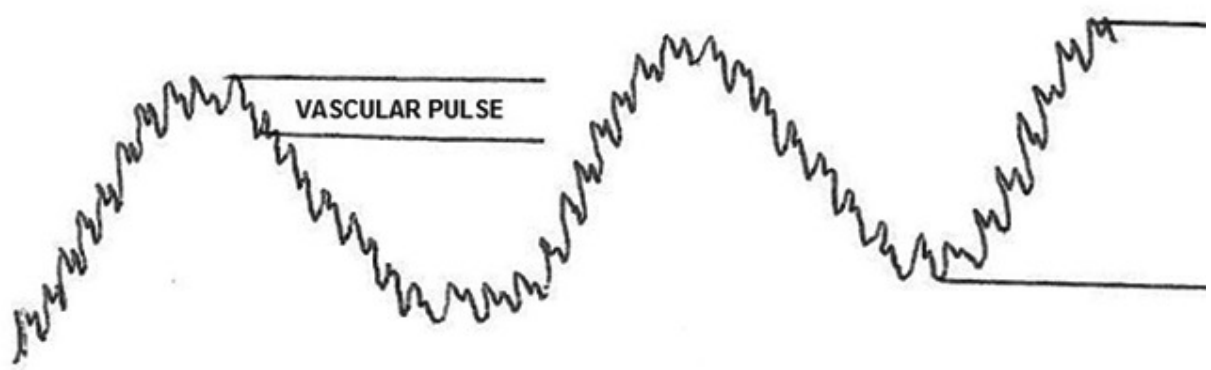
KDAR
FN BRNO a LF MU

- Mozkový perfúzní tlak (cerebral perfusion pressure – CPP), definovaný jako CPP=MAP-ICP, má přímý vztah k mozkové perfúzi. Krom udržení ICP pod terapeutickou cílovou hodnotou 20 mmHg je potřeba udržovat minimální CPP v závislosti od věku pacienta.
- Cíl CPP je pro děti <6 let: 45-55 mmHg, pro děti ≥ 6 let: 50-60 mmHg, pro děti >13 let 60-70 mmHg.

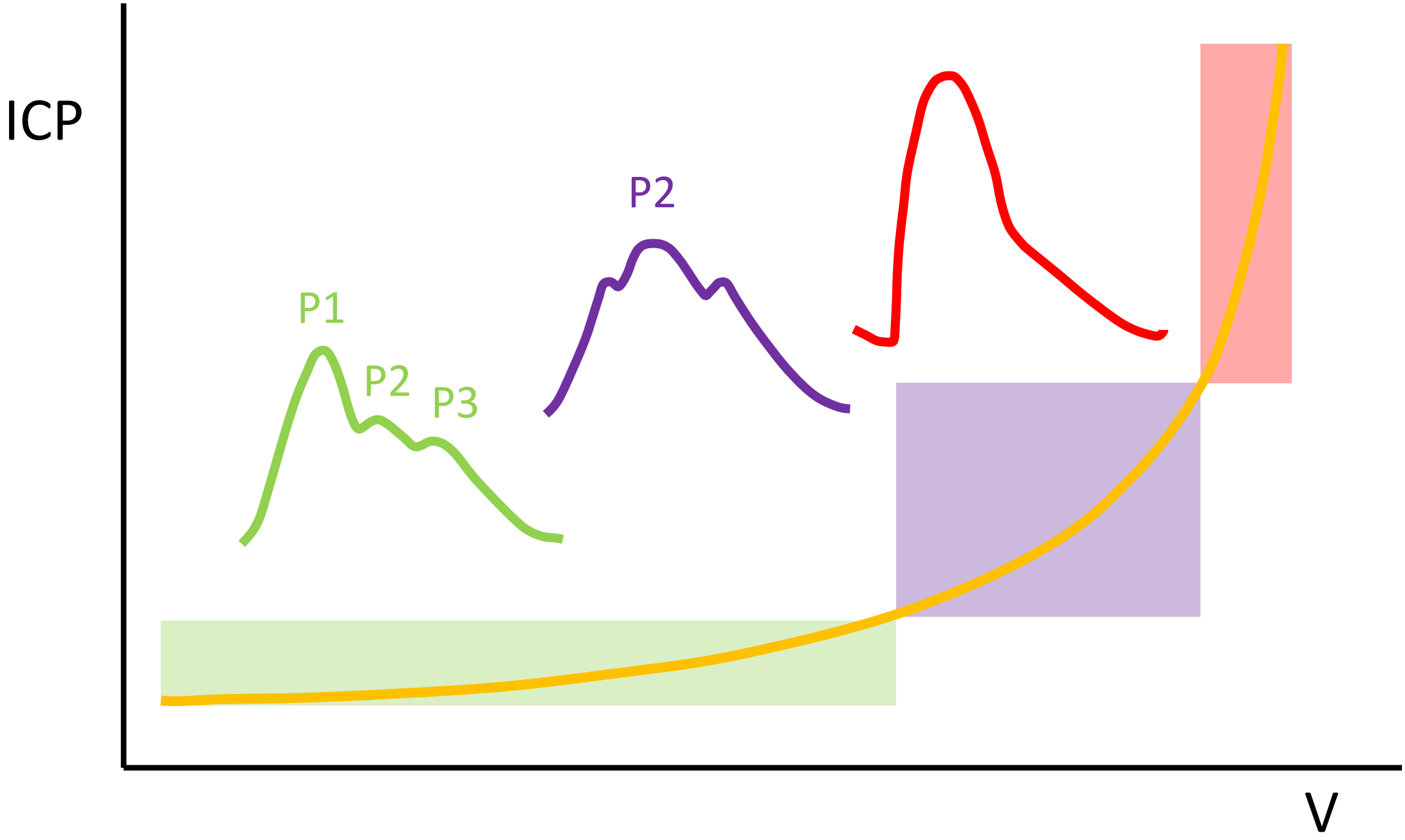

Codman
ICP
12
mmHg
SYS 14
DIAS 9
ICP Express™
MENU
0
20
100
ICP

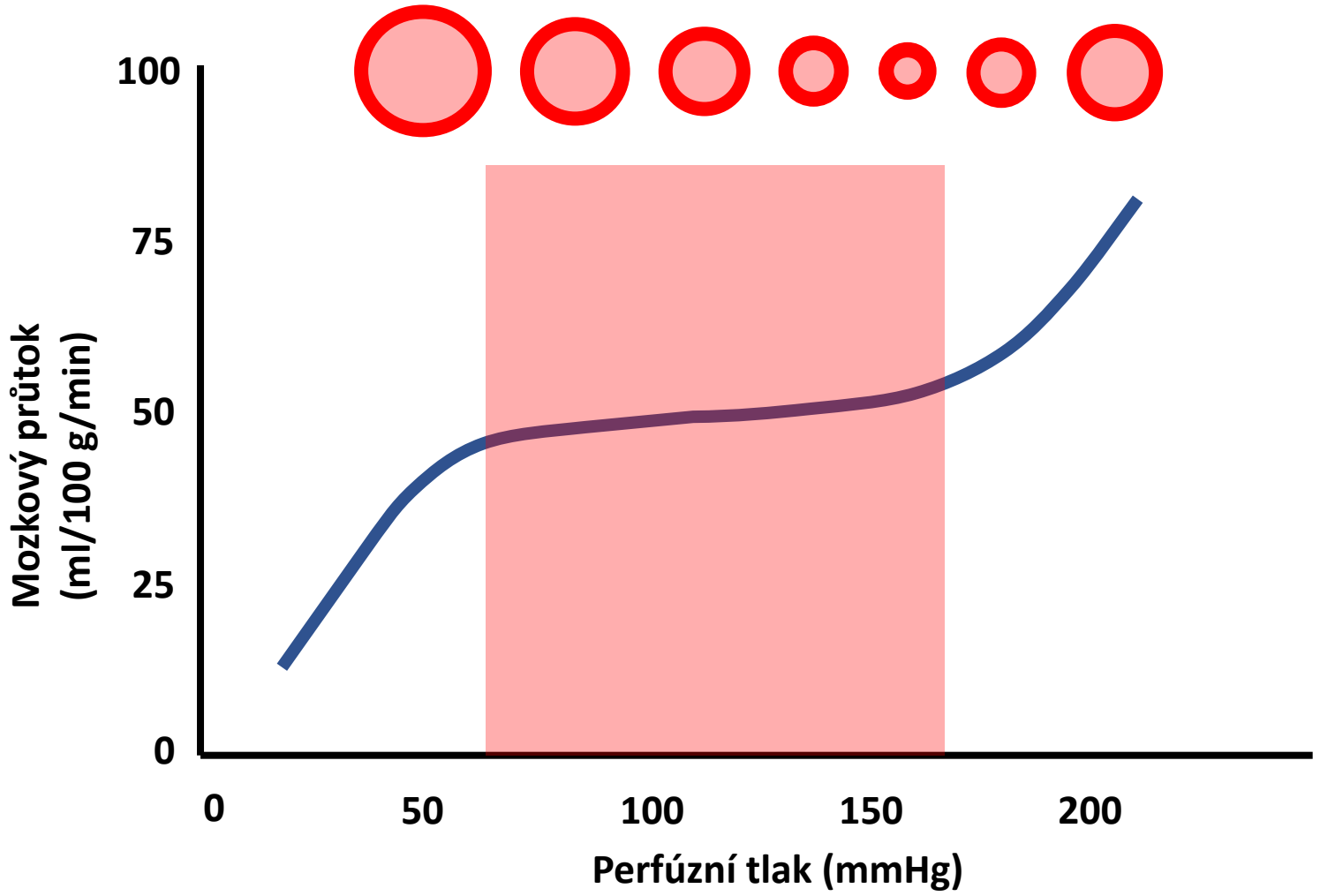

ICP
4
25
-1
CPP
75
100
65
SpO2
99
100

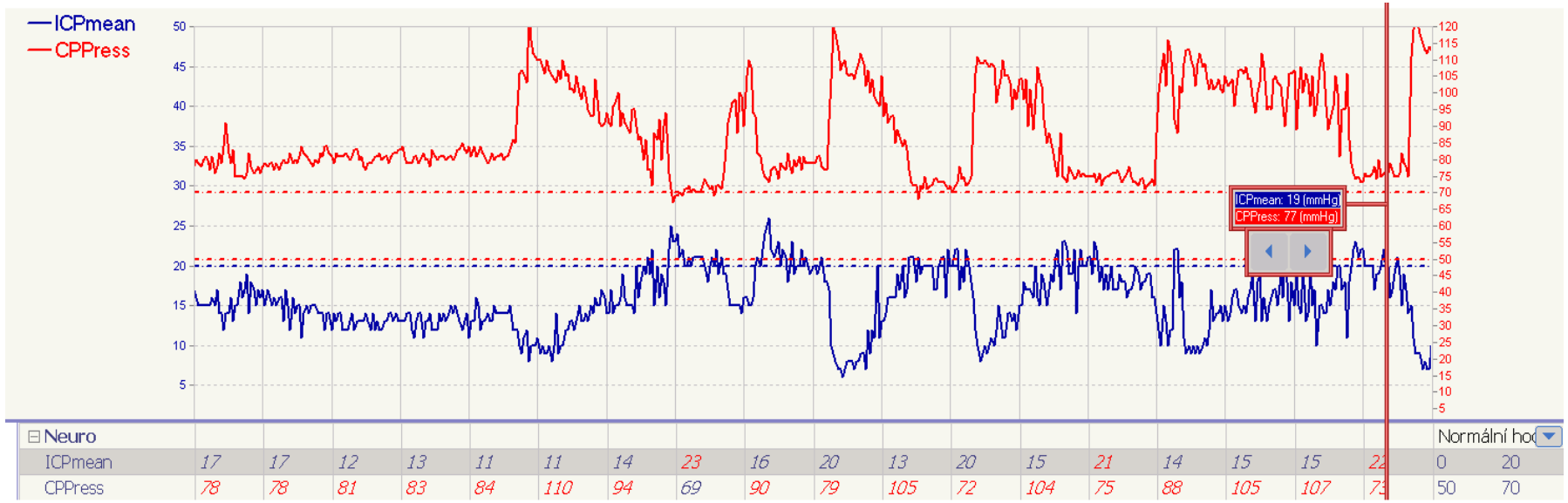
ICP



V


ICP
P1
P2
P3
P2
V

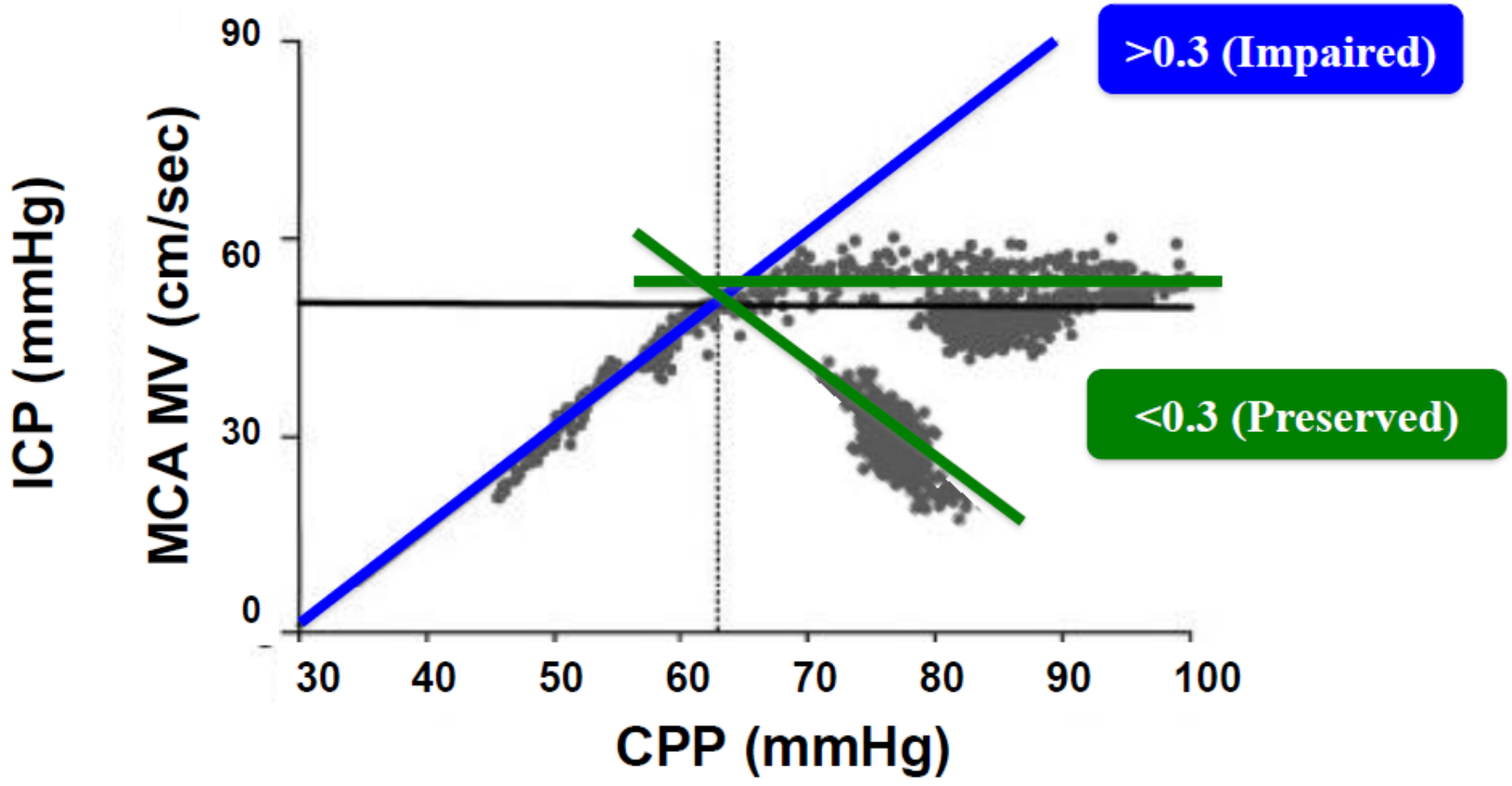

100
75
50
25
0
Mozkový průtok
(ml/100 g/min)
0
50
100
150
200
Perfúzní tlak (mmHg)

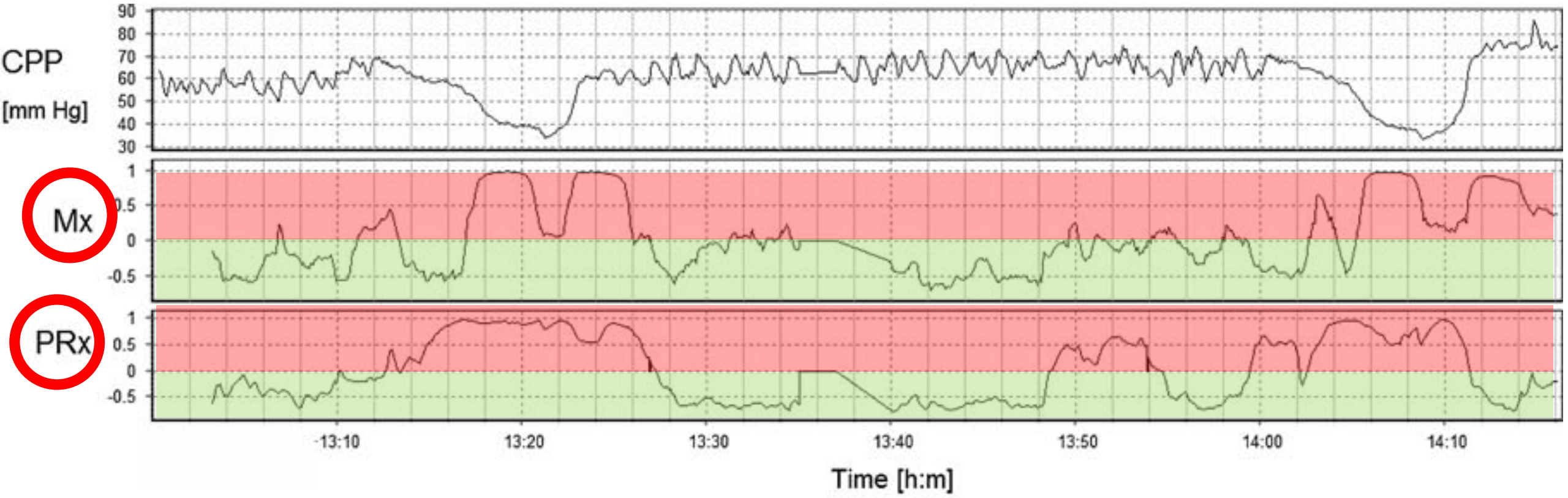


Neuro																			
ICPmean	17	17	12	13	11	11	14	23	16	20	13	20	15	21	14	15	15	22	0	20
CPPress	78	78	81	83	84	110	94	69	90	79	105	72	104	75	88	105	107	73	50	70

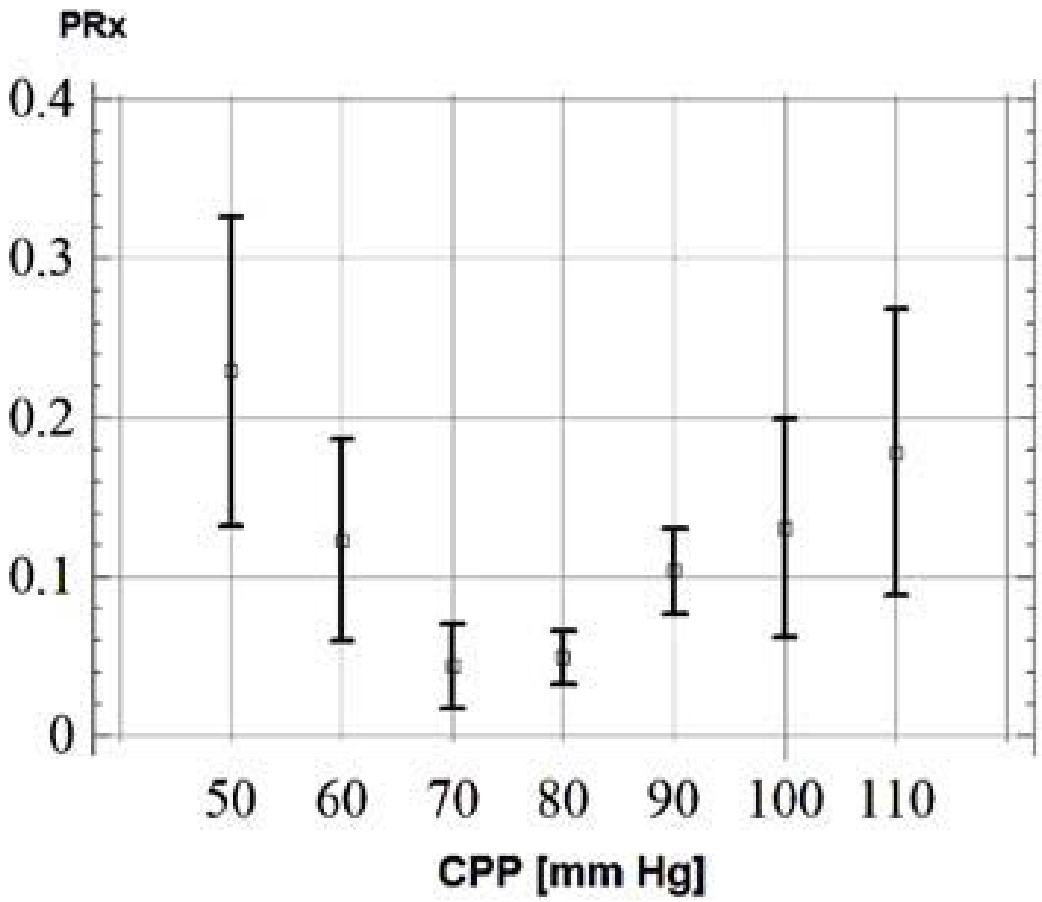
Neuro																							
ICPmean	51	34	47	46	51	49	45	43	56	58	46	43	47	60	56	72	65	58	52	54	54	58	57	58
MAP	93	78	94	97	91	95	85	82	96	88	87	83	83	120	110	115	108	96	95	102	100	103	102	103
CPPress	42	45	47	51	40	48	40	41	38	62	42	41	35	60	53	43	44	40	42	46	46	47	45	47

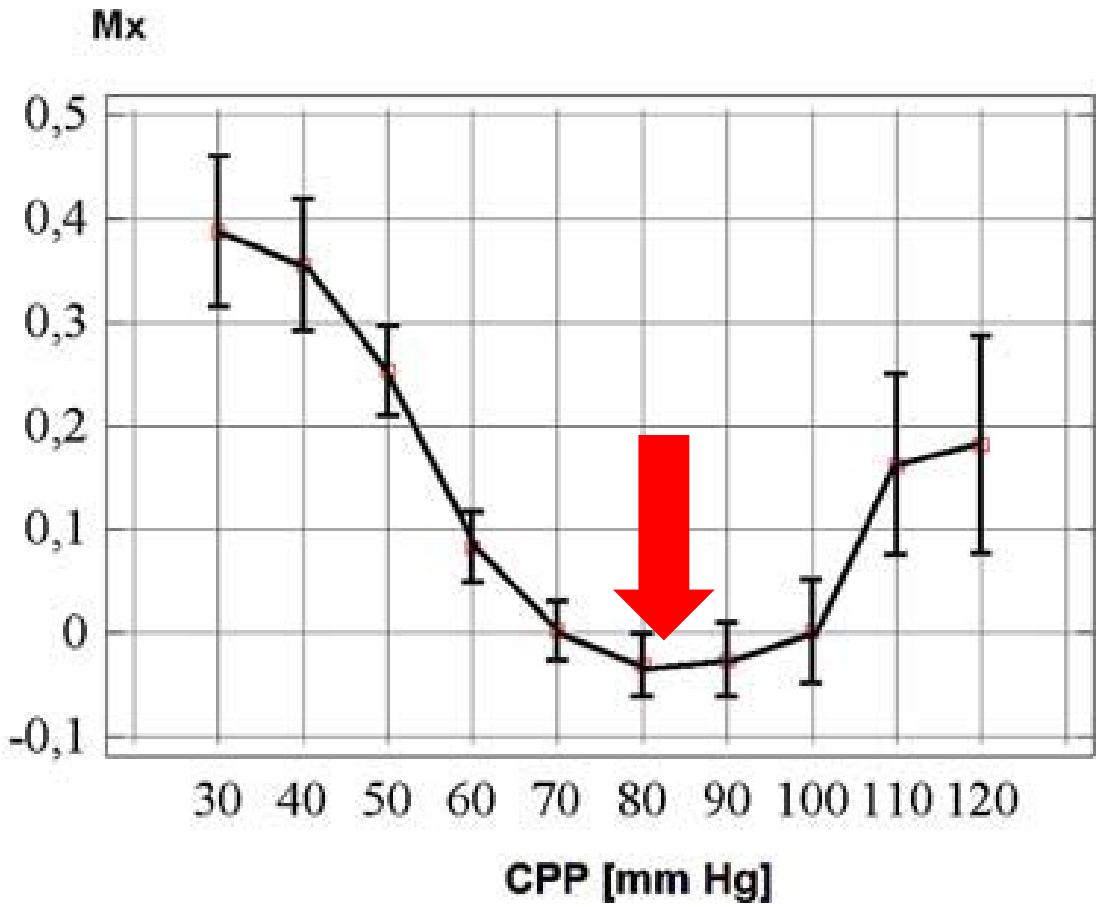
PRx Mx

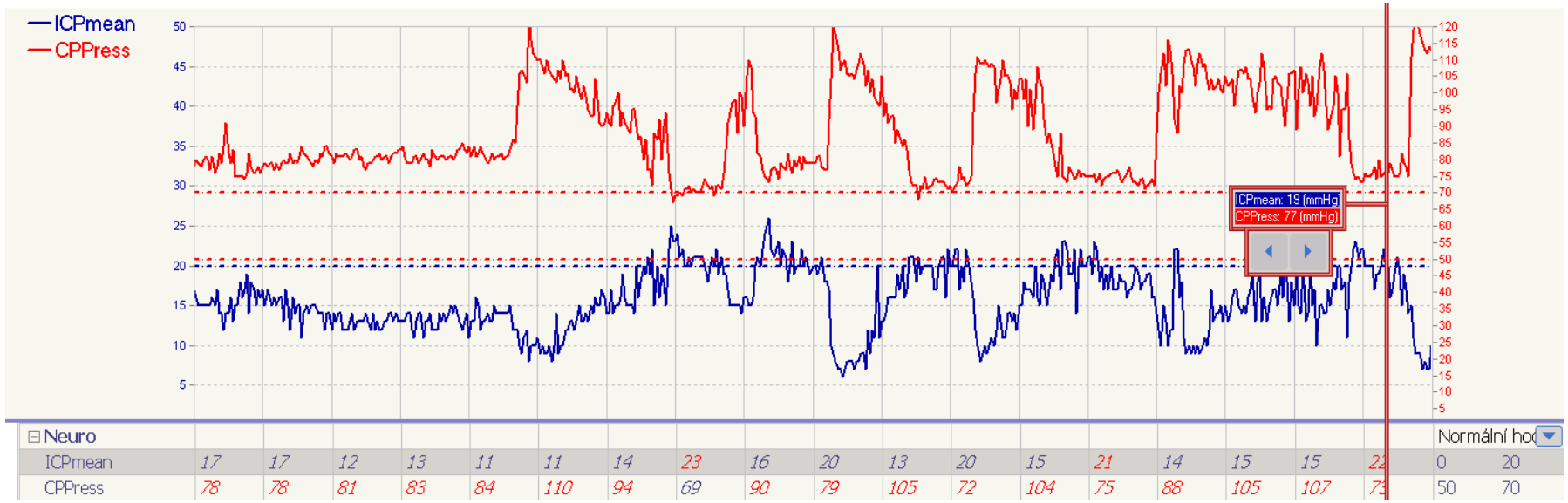

>0.3 (Impaired)
<0.3 (Preserved)
ICP (mmHg)
MCA MV (cm/sec)
90
60
30
0
30
40
50
60
70
80
90
100
CPP (mmHg)



Neurocrit Care (2009) 10:373–386


PRx
0.4
0.3
0.2
0.1
0
50
60
70
80
90
100
110
CPP [mm Hg]


Mx
0,5
0,4
0,3
0,2
0,1
0
-0,1
30
40
50
60
70
80
90
100
110
120
CPP [mm Hg]



Neuro																			
ICPmean	17	17	12	13	11	11	14	23	16	20	13	20	15	21	14	15	15	22	0	20
CPPress	78	78	81	83	84	110	94	69	90	79	105	72	104	75	88	105	107	73	50	70

Neuro																							
ICPmean	51	34	47	46	51	49	45	43	56	58	46	43	47	60	56	72	65	58	52	54	54	58	57	58
MAP	93	78	94	97	91	95	85	82	96	88	87	83	83	120	110	115	108	96	95	102	100	103	102	103
CPPress	42	45	47	51	40	48	40	41	38	62	42	41	35	60	53	43	44	40	42	46	46	47	45	47

Favorable Outcome in Traumatic Brain Injury Patients With Impaired Cerebral Pressure Autoregulation When Treated at Low Cerebral Perfusion Pressure Levels

Ulf Johnson, MD ✉, Pelle Nilsson, MD, PhD, Elisabeth Ronne-Engström, MD, PhD, Tim Howells, PhD, Per Enblad, MD, PhD

Neurosurgery, Volume 68, Issue 3, 1 March 2011, Pages 714–722,

patients with more intact CPA when divided by level of CPP. In patients with more impaired CPA, CPP < 50 mm Hg and CPP < 60 mm Hg were associated with favorable outcome, whereas CPP > 70 mm Hg and CPP > 80 mm Hg were associated with unfavorable outcome.

Zlepšuje ICP monitoring outcome?

J Neurosurg 117:729–734, 2012

Increased mortality in patients with severe traumatic brain injury treated without intracranial pressure monitoring

Clinical article

ARASH FARAHVAR, M.D., PH.D.,[1] LINDA M. GERBER, PH.D.,[2] YA-LIN C
NANCY CARNEY, PH.D.,[3] ROGER HÄRTL, M.D.,[4] AND JAMSHID GHAJAR,

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Health and [4]Neurological Surgery, Weill Cornell Medical College; and [5]Brain Tra
New York, New York; and [3]Department of Medical Informatics and Clinical Epide
Health & Science University, Portland, Oregon

TABLE 3: Logistic regression analyses predicting 2-week mortality for all 1446 patients and for the subpopulation of 1307 adult patients

	Adults		All Ages	
Predictor Variable	Adjusted OR (95% CI)	p Value	Adjusted OR (95% CI)	p Value
ICP monitoring				
yes	0.64 (0.41–1.00)	0.05	0.63 (0.41–0.94)	0.02
no	reference		reference	
age (yrs)				
≥60	2.43 (1.56–3.79)	<0.0001	2.50 (1.65–3.78)	<0.0001
<60	reference		reference	
initial GCS score				
6–8	0.46 (0.37–0.57)	<0.0001	0.44 (0.36–0.53)	<0.0001
3–5	reference		reference	
hypotension present on Day 1				
yes	2.08 (1.48–2.92)	<0.0001	2.08 (1.54–2.82)	<0.0001
no	reference		reference	
CT scan findings				
abnormal	2.45 (1.05–5.75)	0.04	2.71 (1.11–6.60)	0.03
normal	reference		reference	
pupil abnormalities on Day 1				
yes	1.38 (0.99–1.91)	0.05	1.40 (0.98–2.00)	0.07
no	reference		reference	

JOURNAL OF NEUROTRAUMA 30:1737–1746 (October 15, 2013)

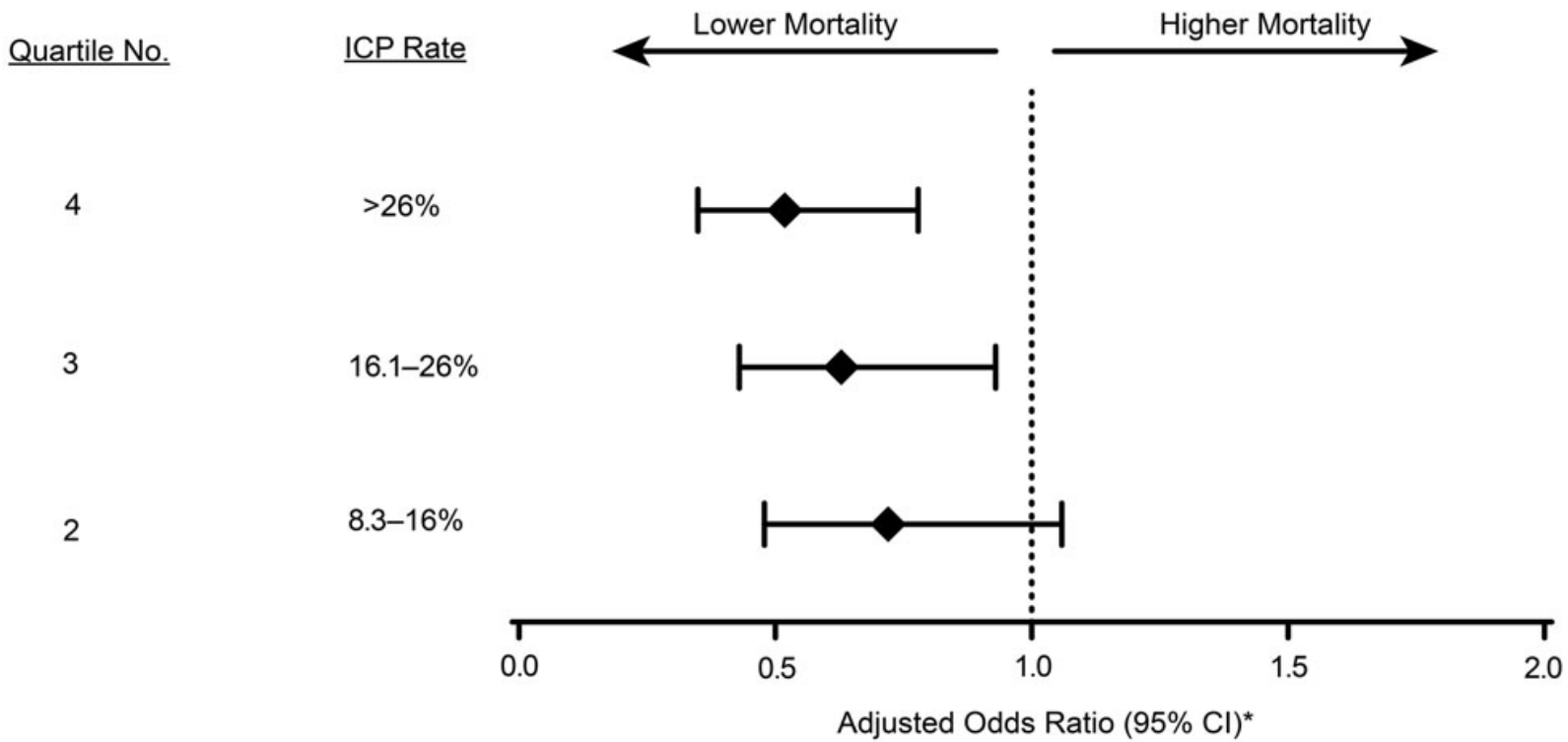
DOI: 10.1089/neu.2012.2802

Intracranial Pressure Monitoring in Severe Traumatic Brain Injury: Results from the American College of Surgeons Trauma Quality Improvement Program

Aziz S. Alali,[1–3] Robert A. Fowler,[1,2,4,5] Todd G. Mainprize,[6] Damon C. Scales,[1,2,4,5] Alexander Kiss,[1,2,7] Charles de Mestral,[1,10] Joel G. Ray,[2,8,9] and Avery B. Nathens[1,2,8,10]

OR for death 0,44 (CI 0,31 – 0,63), p 0,0001

OR for death 0.52 (95% CI, 0.35–0.78)



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., for the Global Neurotrauma Research Group*

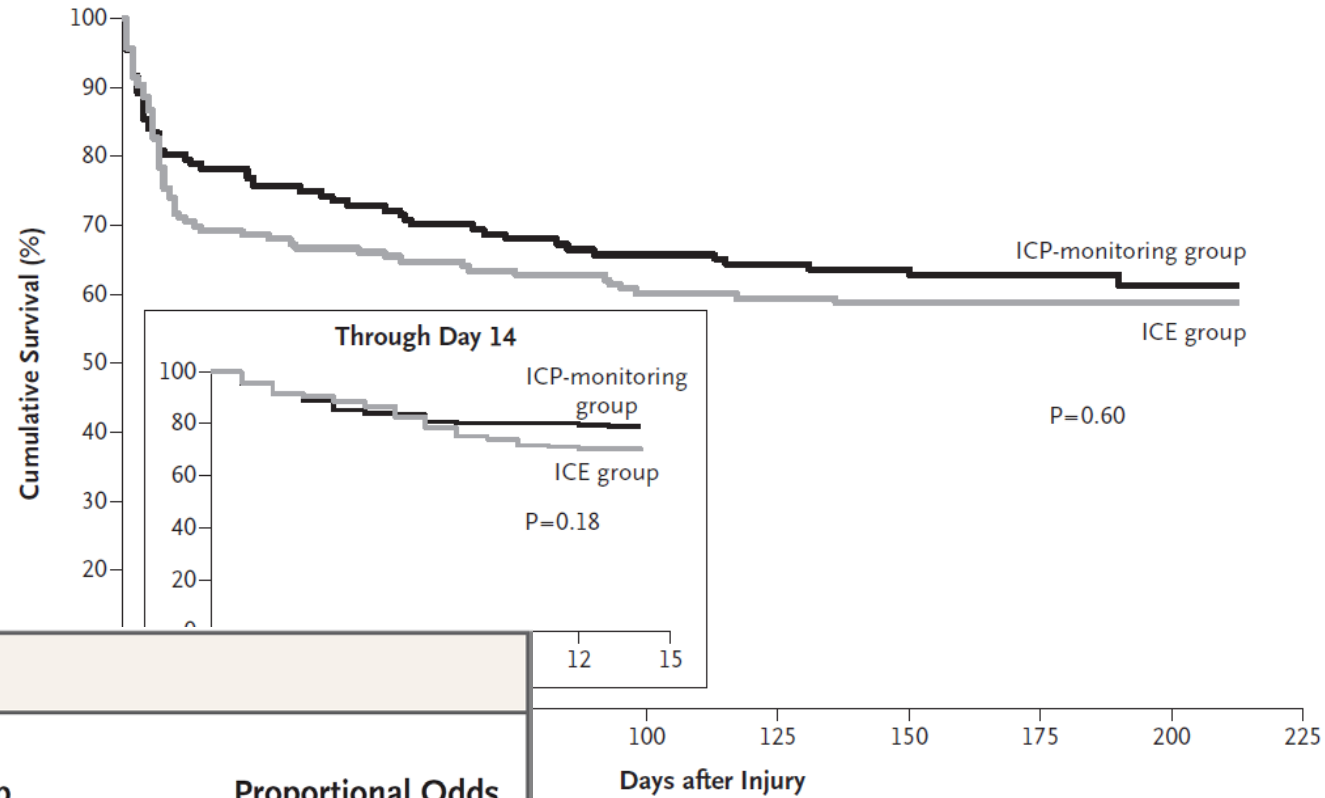


Table 2. Clinical Outcomes.*

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‡			0.49§	1.09 (0.74–1.58)
Median	56	53		
Interquartile range	22–77	21–76		
Cumulative mortality at 6 mo — %	39	41	0.60¶	1.10 (0.77–1.57)
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)		

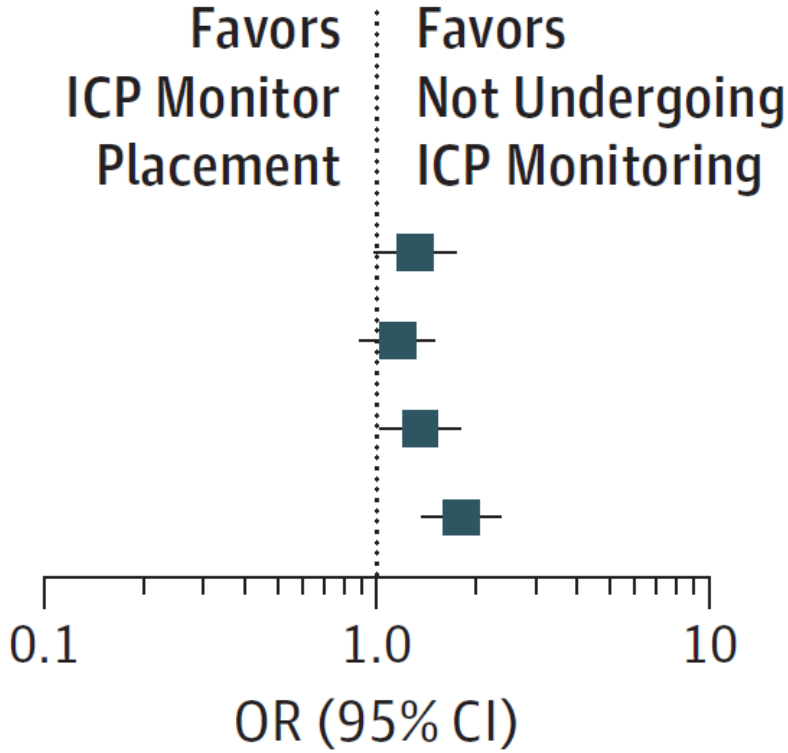
JAMA Pediatrics | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Functional Outcome After Intracranial Pressure Monitoring for Children With Severe Traumatic Brain Injury

Tellen D. Bennett, MD, MS; Peter E. DeWitt, MS; Tom H. Greene, PhD; Rajendu Srivastava, MD, MPH; Jay Riva-Cambrin, MD, MSc; Michael L. Nance, MD; Susan L. Bratton, MD, MPH; Desmond K. Runyan, MD, DrPH; J. Michael Dean, MD, MBA; Heather T. Keenan, MDCM, PhD

A ICP vs No ICP

Model	OR (95% CI)
Primary	1.31 (0.99-1.74)
Mortality	1.16 (0.89-1.50)
Trach or mortality	1.35 (1.02-1.79)
GT or mortality	1.80 (1.37-2.37)



JAMA Pediatr. 2017;171(10):965-971

- Rozhodnout, jestli monitorovat
- Jak monitorovat?
- Jaké informace jsem schopen získat?
- Jak léčit na základě ICP monitoringu?

- Zahájit léčbu při ICP >20 mmHg (setrvalé výstupy > 1 minutu)
- CPP nastavit individuálně podle věku 40-50-60 mmHg
- Při výrazné elevaci hlavy, u vysokých pacientů vyšší
- Při zachované autoregulaci CPP >65 (pokud nestoupá ICP)
- Při poruše autoregulace MAP >65, CPP 50-60 mmHg

Děkuji za pozornost