Neuromonitorace v IP/anestézii

TOMÁŠ TYLL

ÚVN
ÚSTŘEDNÍ VOJENSKÁ NEMOCNICE
Vojenská fakultní nemocnice Praha

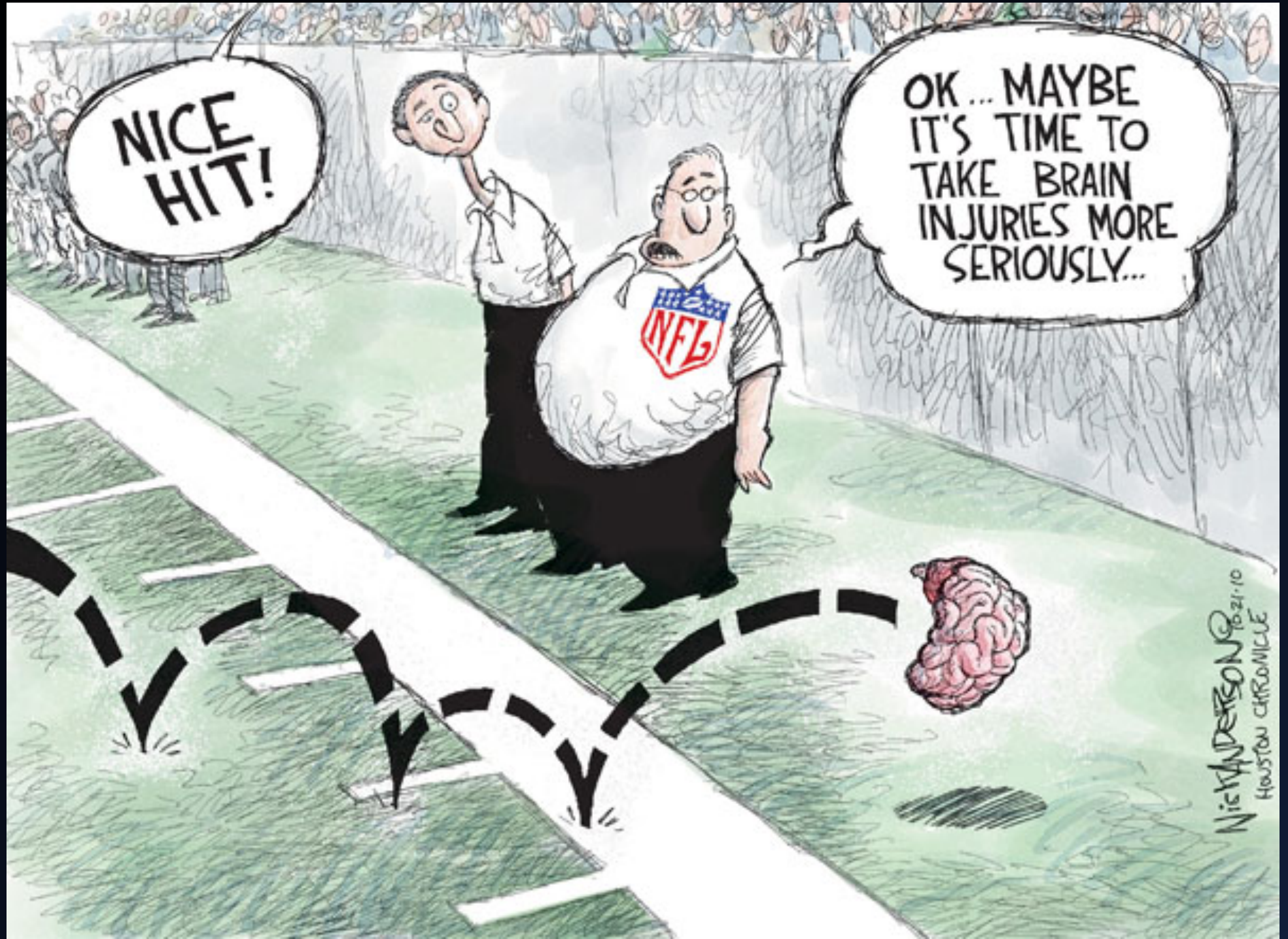


ŠKOLENÍ PRIMÁŘŮ NEUROLOGIE I 2025

Update ?

- Úvod
- Modality
- Závěr

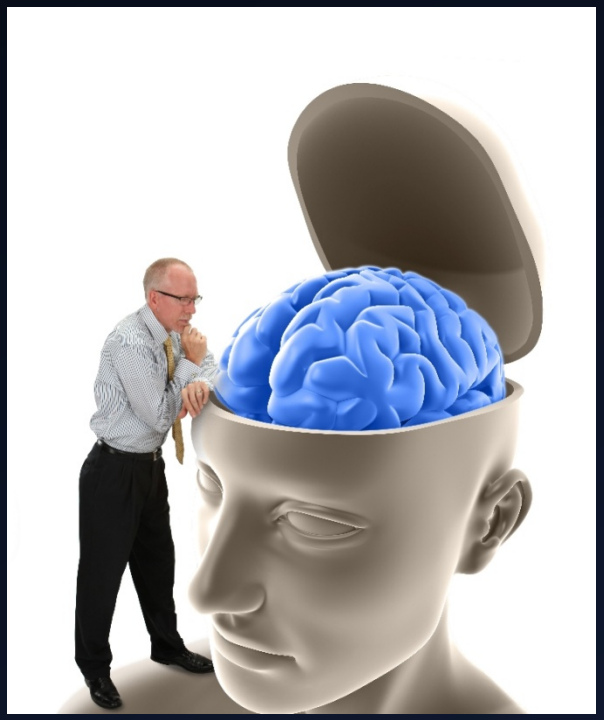



NICE HIT!
OK... MAYBE IT'S TIME TO TAKE BRAIN INJURIES MORE SERIOUSLY...
NFL
NICK ANDERSON 10.21.10
HOUSTON CHRONICLE

Cíle monitorování

- Prevece
- Identifikace
- Řízení
- Prognóza

- Prevence sekundárního poškození



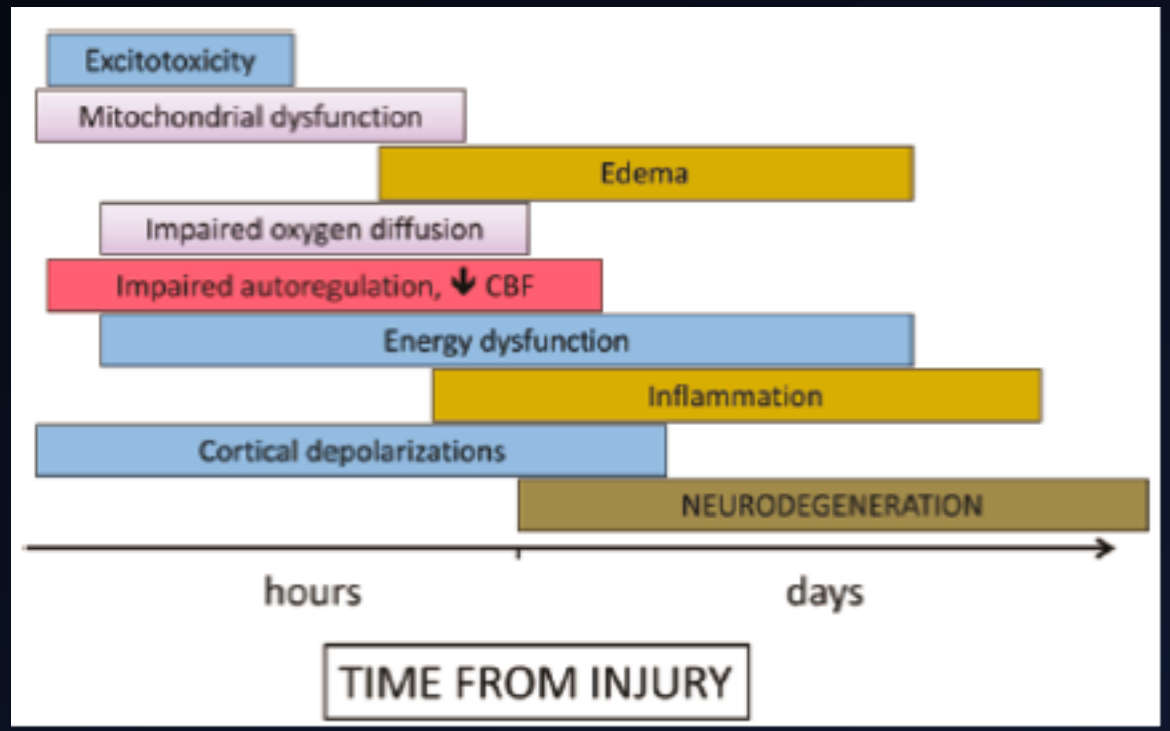
Terapie

Definované cíle

nebo

Individualizovaná léčba





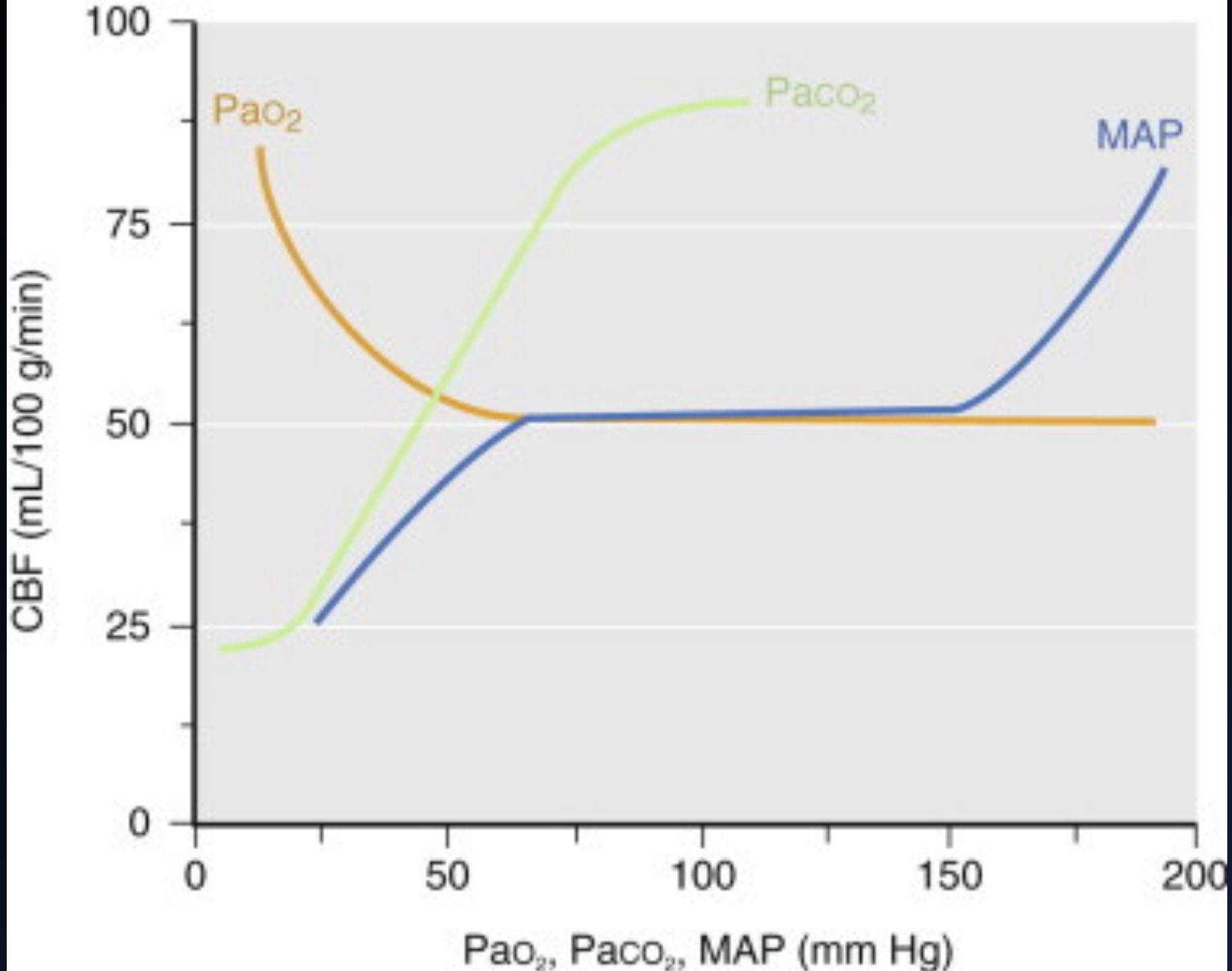
Stocchetti *et al. Critical Care* 2013, 17:201
http://ccforum.com/content/17/1/201

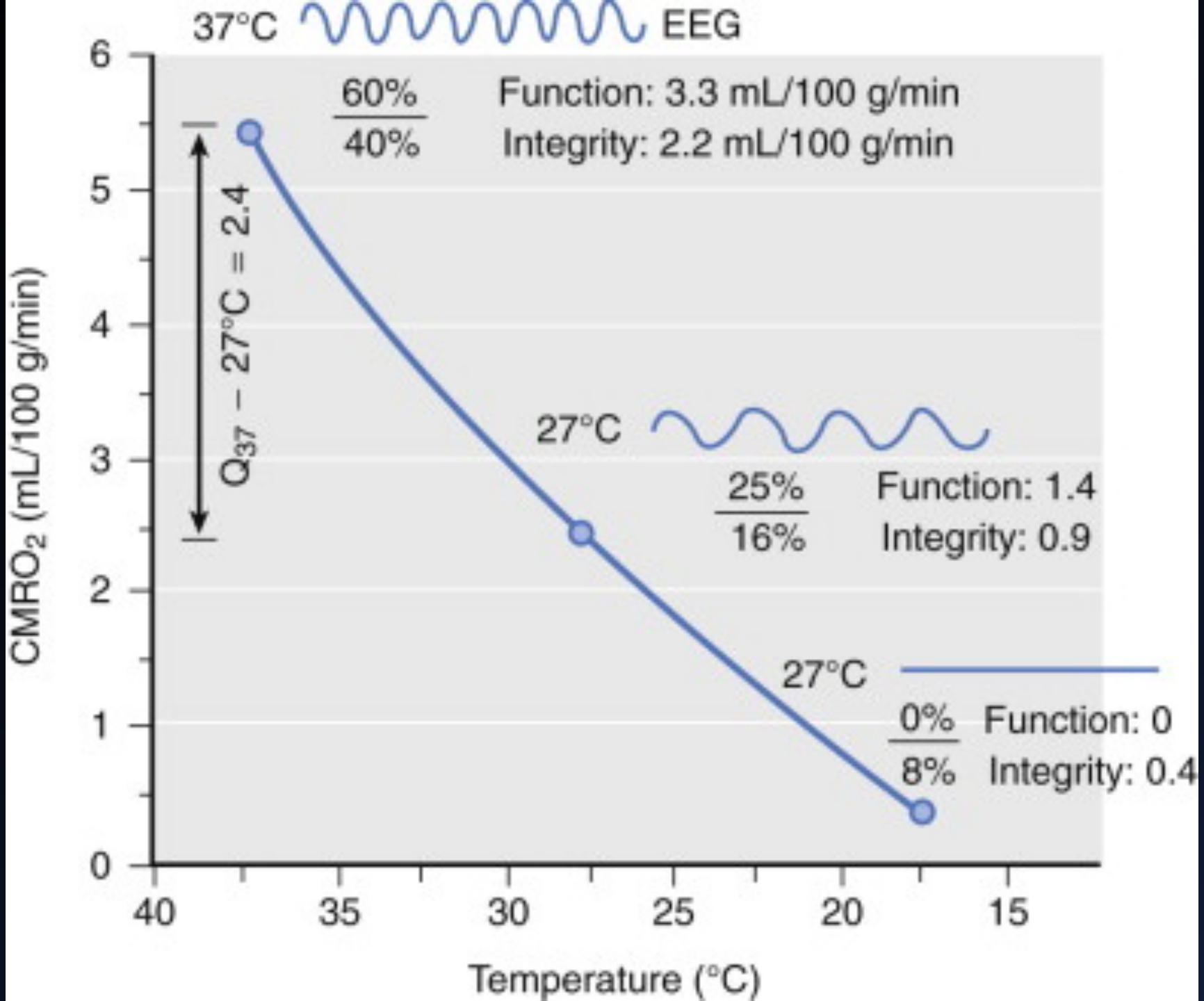
Jen specifické!!

- Hemodynamika
- Ventilace
- Teplota
- Bilance tekutin
- Vnitřní prostředí…

Consensus Summary Statement of the International Multidisciplinary Consensus Conference on Multimodality Monitoring in Neurocritical Care

A statement for healthcare professionals from the Neurocritical Care Society and the European Society of Intensive Care Medicine

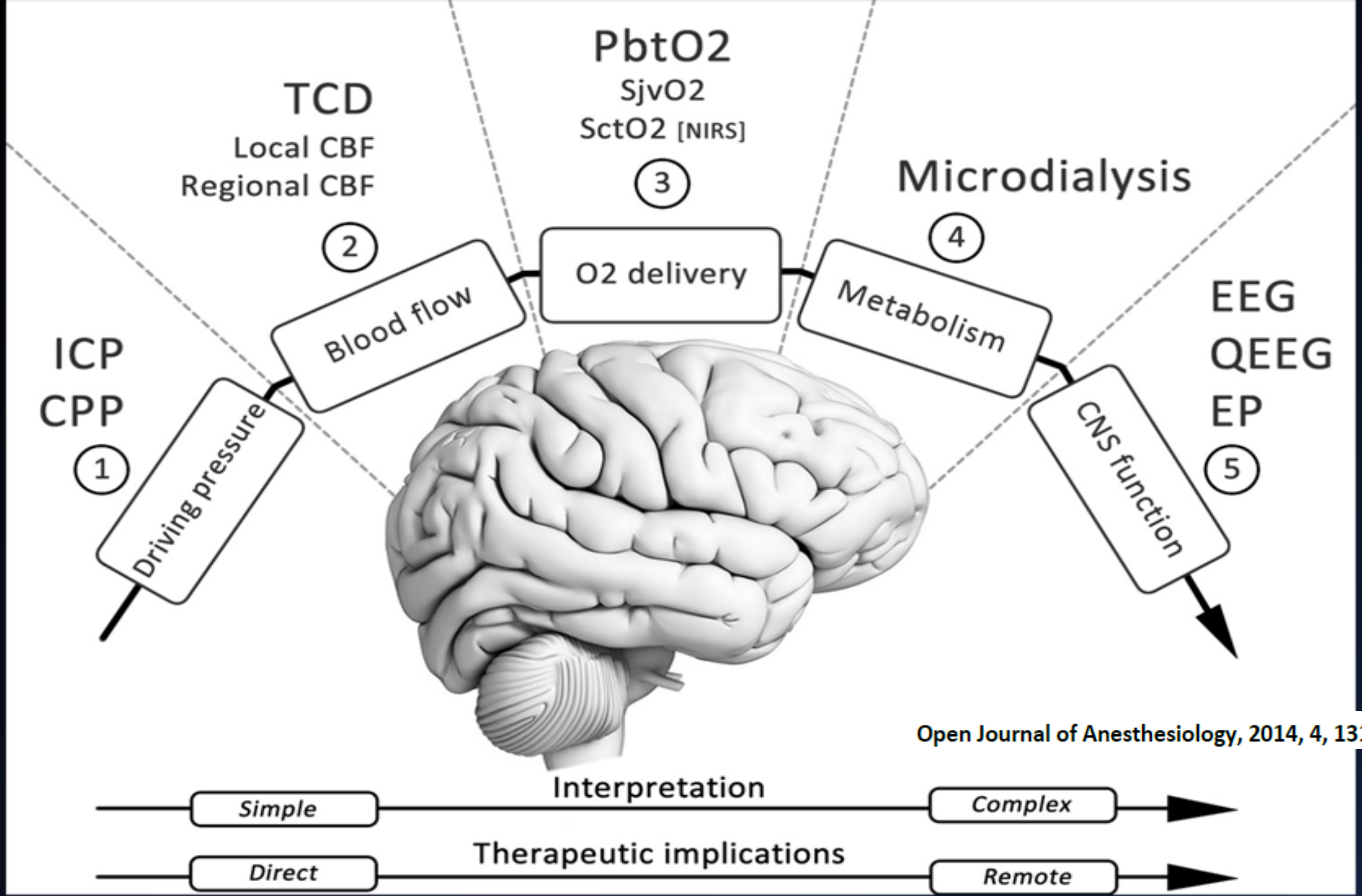

100
75
50
25
0
CBF (mL/100 g/min)
Pao_2
$Paco_2$
MAP
0
50
100
150
200
Pao_2, $Paco_2$, MAP (mm Hg)


37°C
EEG
60%
40%
Function: 3.3 mL/100 g/min
Integrity: 2.2 mL/100 g/min
$Q_{37} - 27°C = 2.4$
27°C
25%
16%
Function: 1.4
Integrity: 0.9
27°C
0%
8%
Function: 0
Integrity: 0.4
$CMRO_2$ (mL/100 g/min)
0
1
2
3
4
5
6
40
35
30
25
20
15
Temperature (°C)

Rozdělení

- Invazivní x neinvazivní
- Globální x regionální
- Spontánní x vyvolané

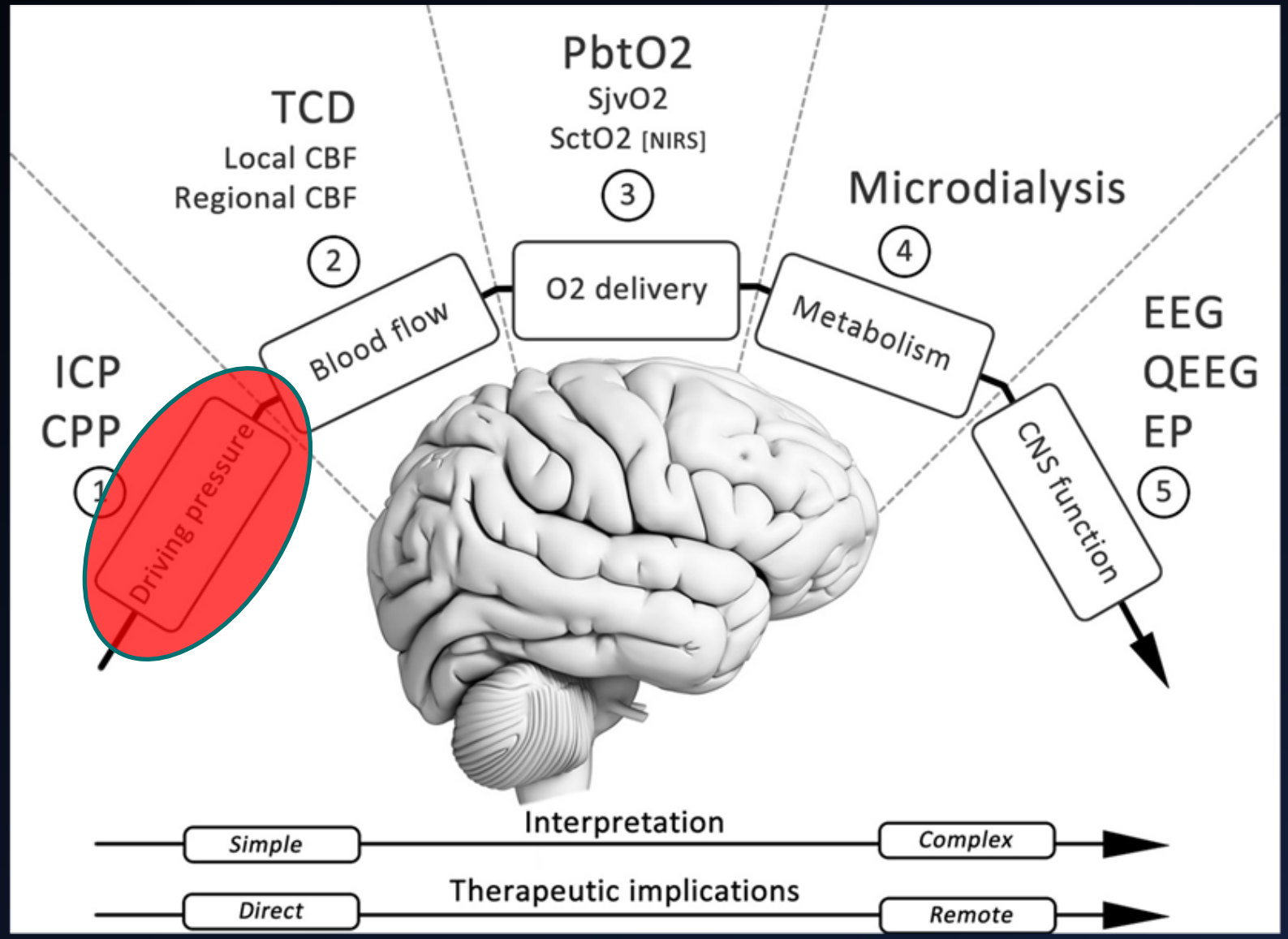
…

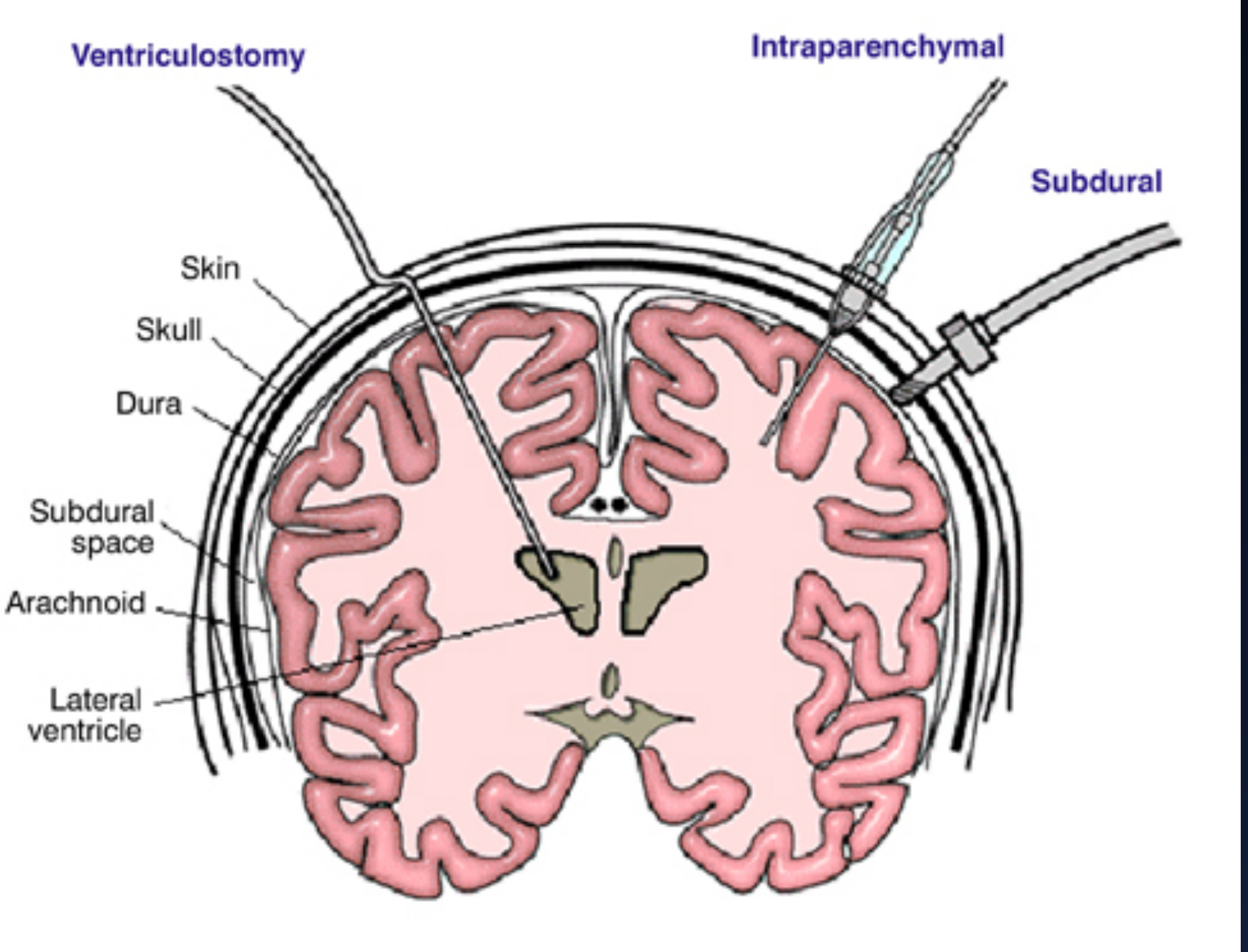


Open Journal of Anesthesiology, 2014, 4, 131-152

I. Tlaky

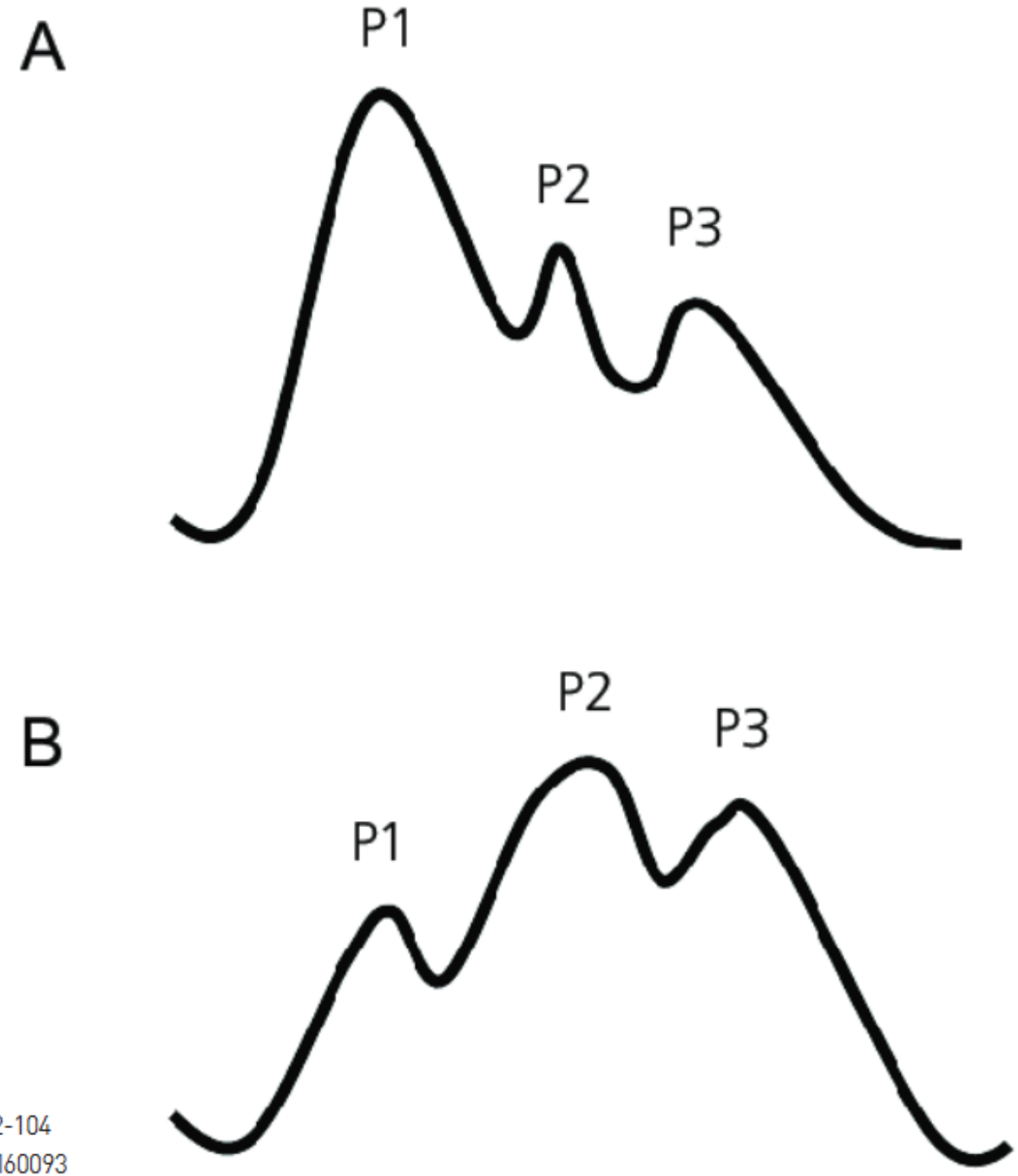
- ICP
- CPP
  - Autoregulace




Ventriculostomy
Intraparenchymal
Subdural
Skin
Skull
Dura
Subdural space
Arachnoid
Lateral ventricle

ICP - invazivně

- EVD
  + terapie
- Převodník
- Umístění



J Neurocrit Care 2016;9(2):92-104
https://doi.org/10.18700/jnc.160093

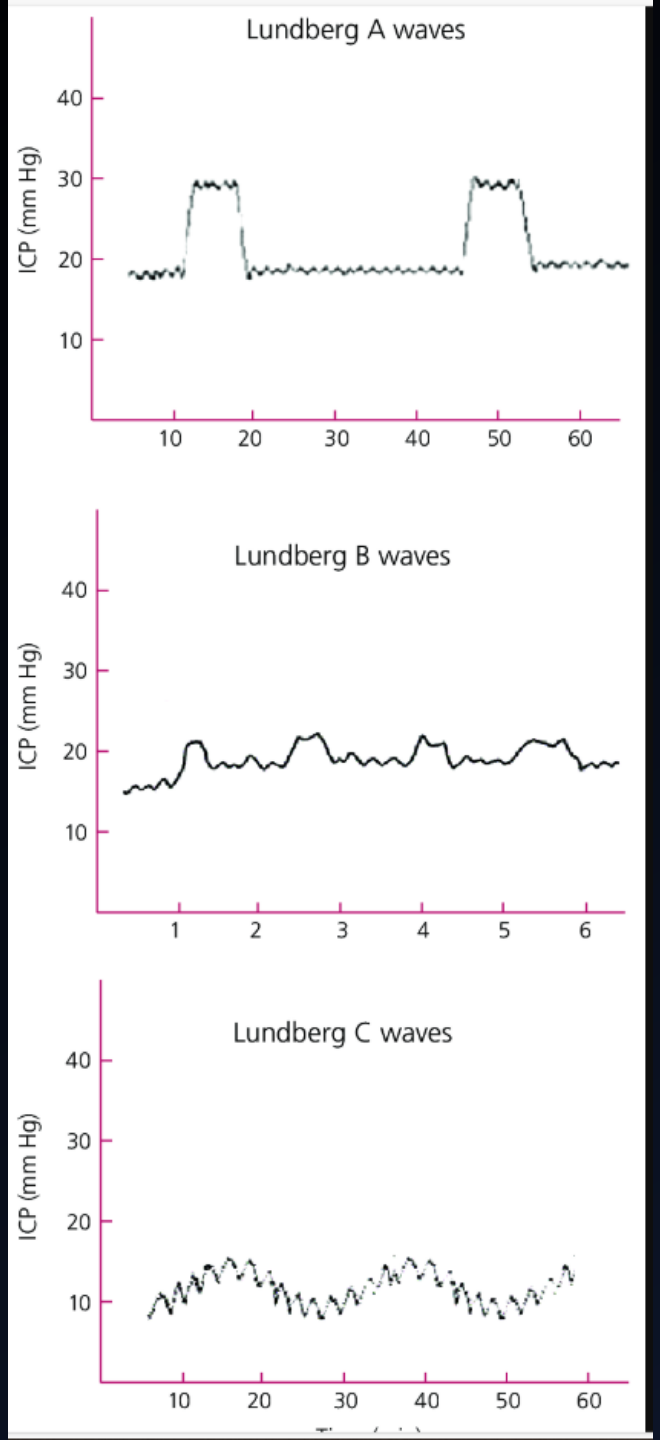


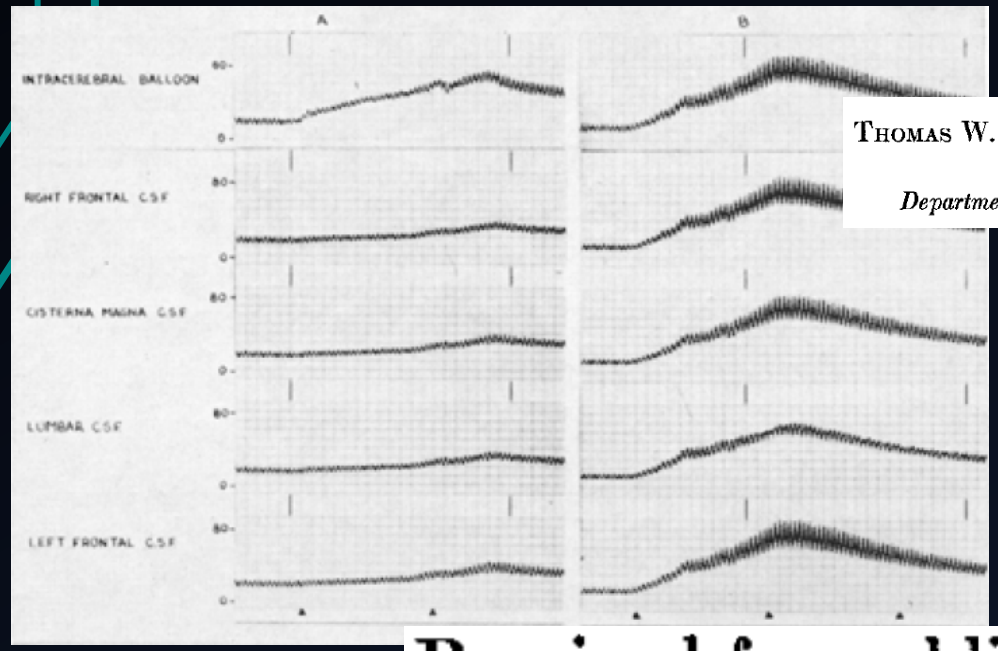
Figure 2. Lundberg waves. Lundberg A waves are ICP increases for 5 to 10 minutes. They reflect reduced cerebral compliance and impending herniation. Lundberg B waves have unclear value in clinical practice. Lundberg C waves are thought to reflect normal interactions between the cardiac and pulmonary cycles. ICP, intracranial pressure.

Je tak všude v mozkovně stejný?

Transmission of Increased Intracranial Pressure

I. Within the Craniospinal Axis*

II. Within the Supratentorial Space*

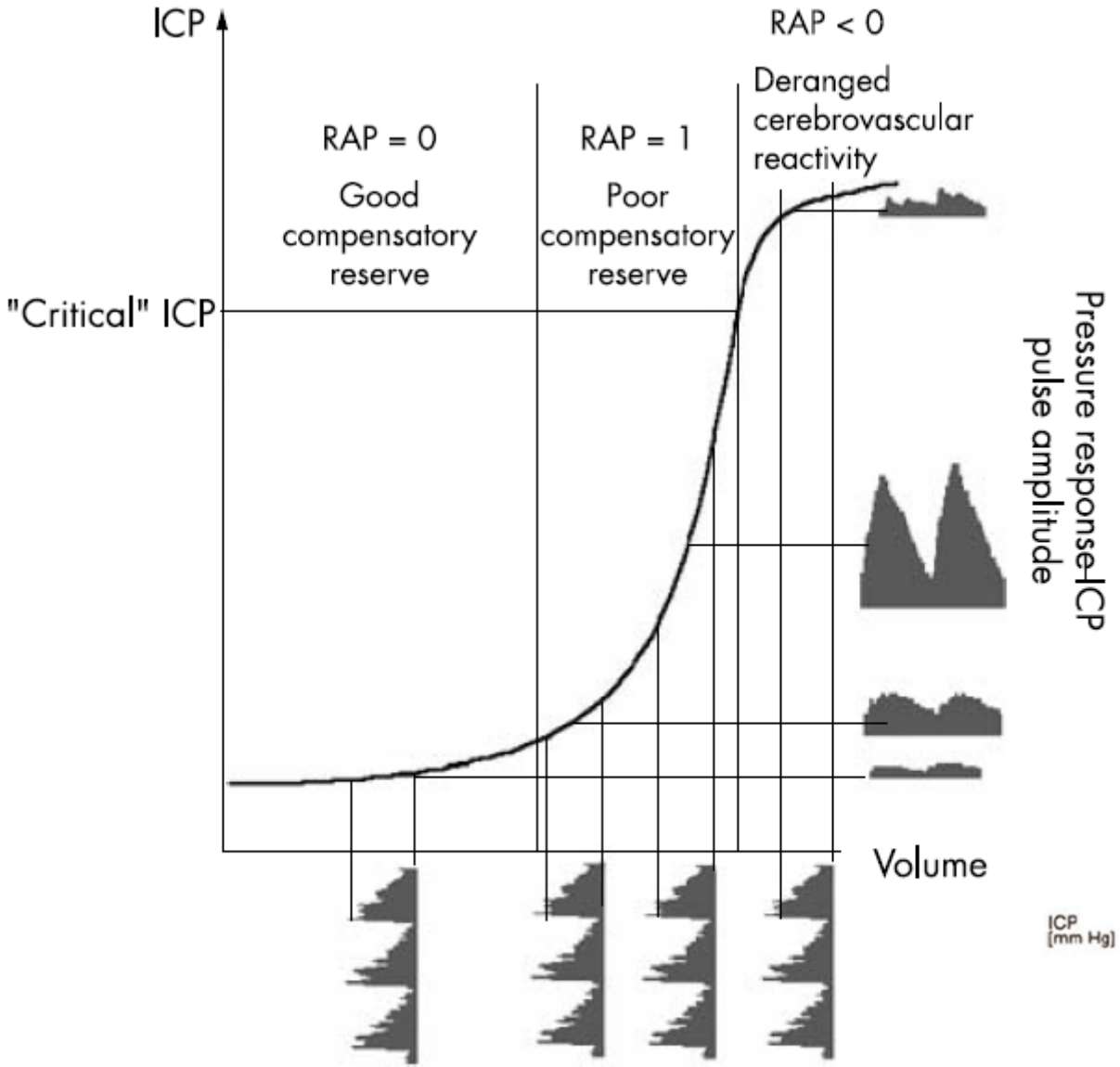


THOMAS W. LANGFITT, M.D., JAMES D. WEINSTEIN, B.S., NEAL F. KASSELL, AND L. JOHN GAGLIARDI, B.S.
Department of Neurosurgery, Pennsylvania Hospital, Philadelphia, Pennsylvania

J. Neurosurg.

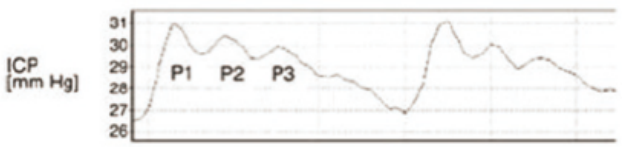
Received for publication December 16, 1963.





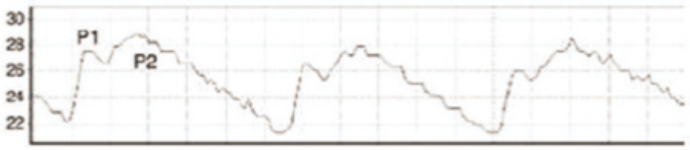
Stocchetti *et al*. *Critical Care* 2013, **17**:201
http://ccforum.com/content/17/1/201

Normal compliance



➢ P1-predominant pattern wave

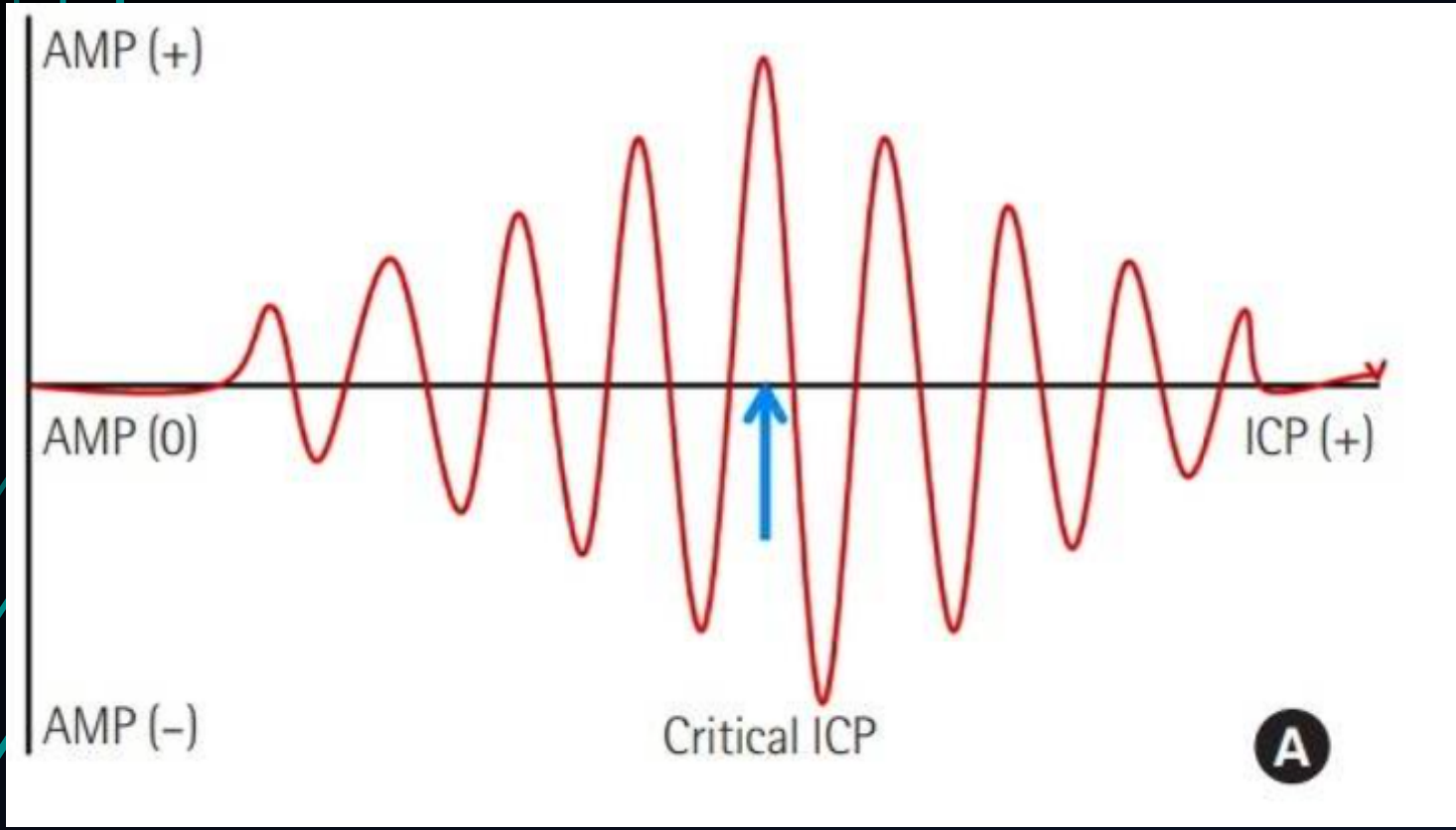
Reduced compliance

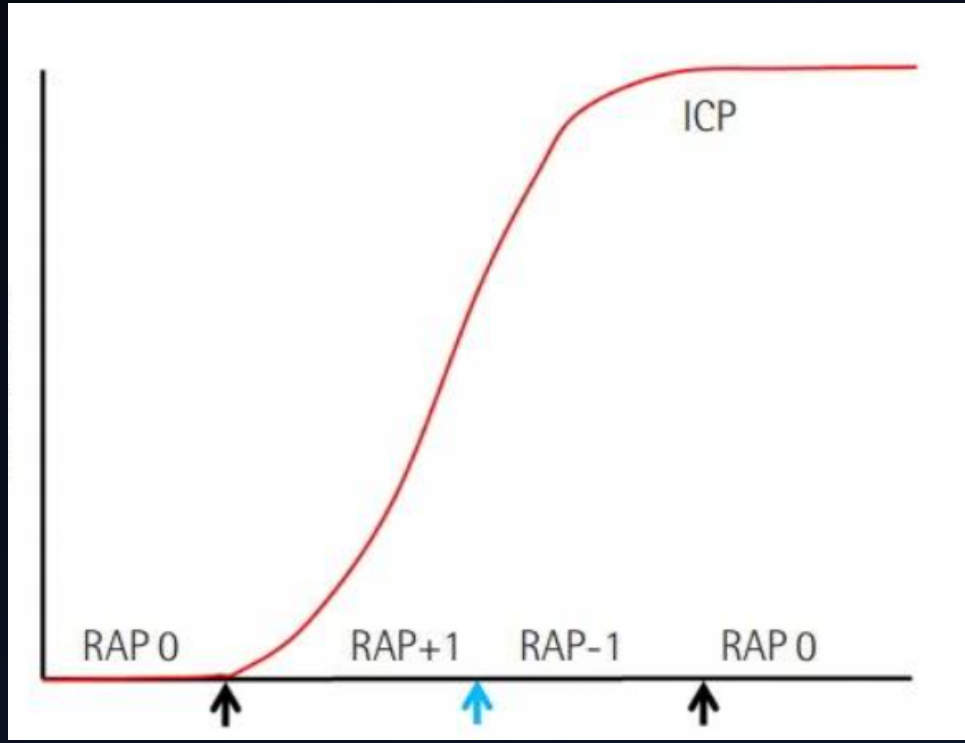


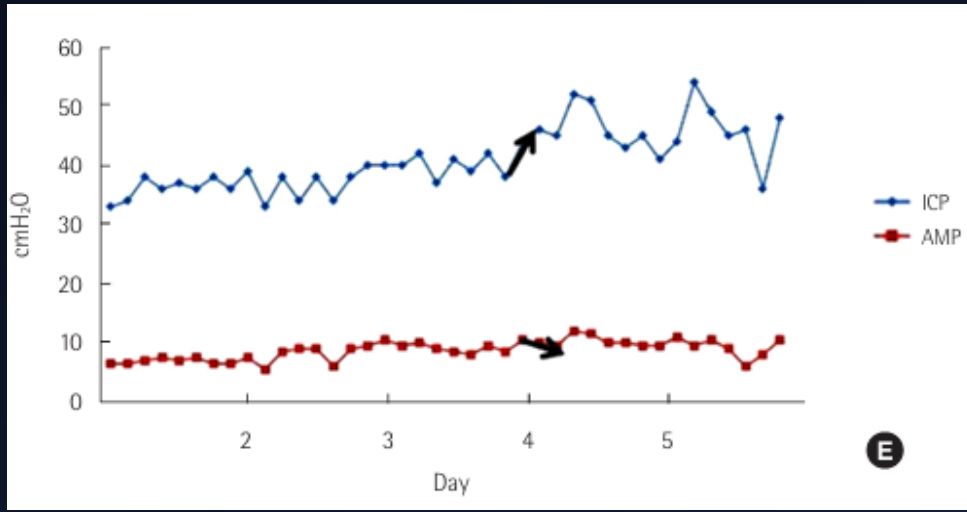
➢ P2-predominant pattern wave

J Neurol Neurosurg Psychiatry 2004;**75**:813–821. doi: 10.1136/jnnp.2003.033126

RAP



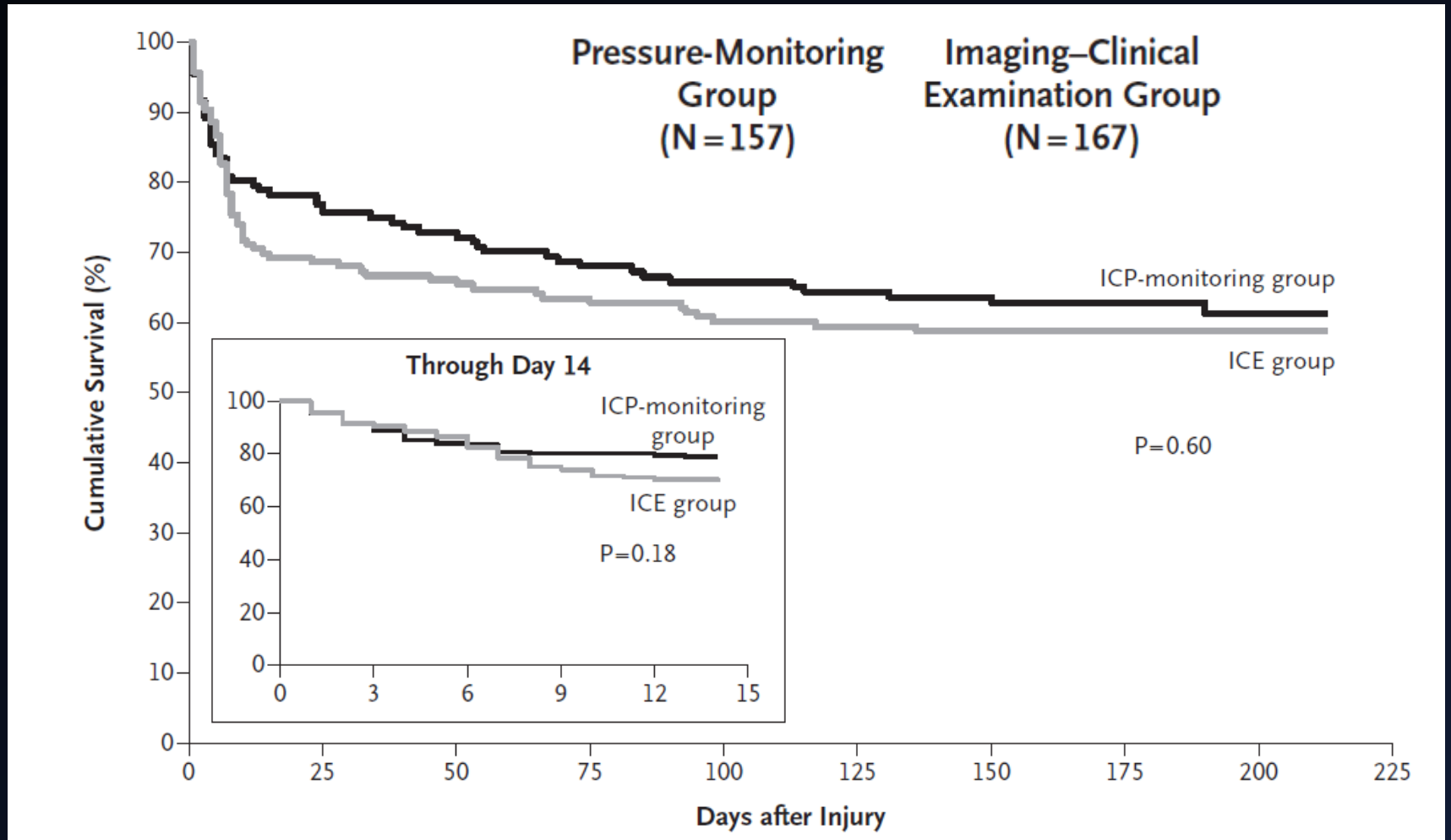




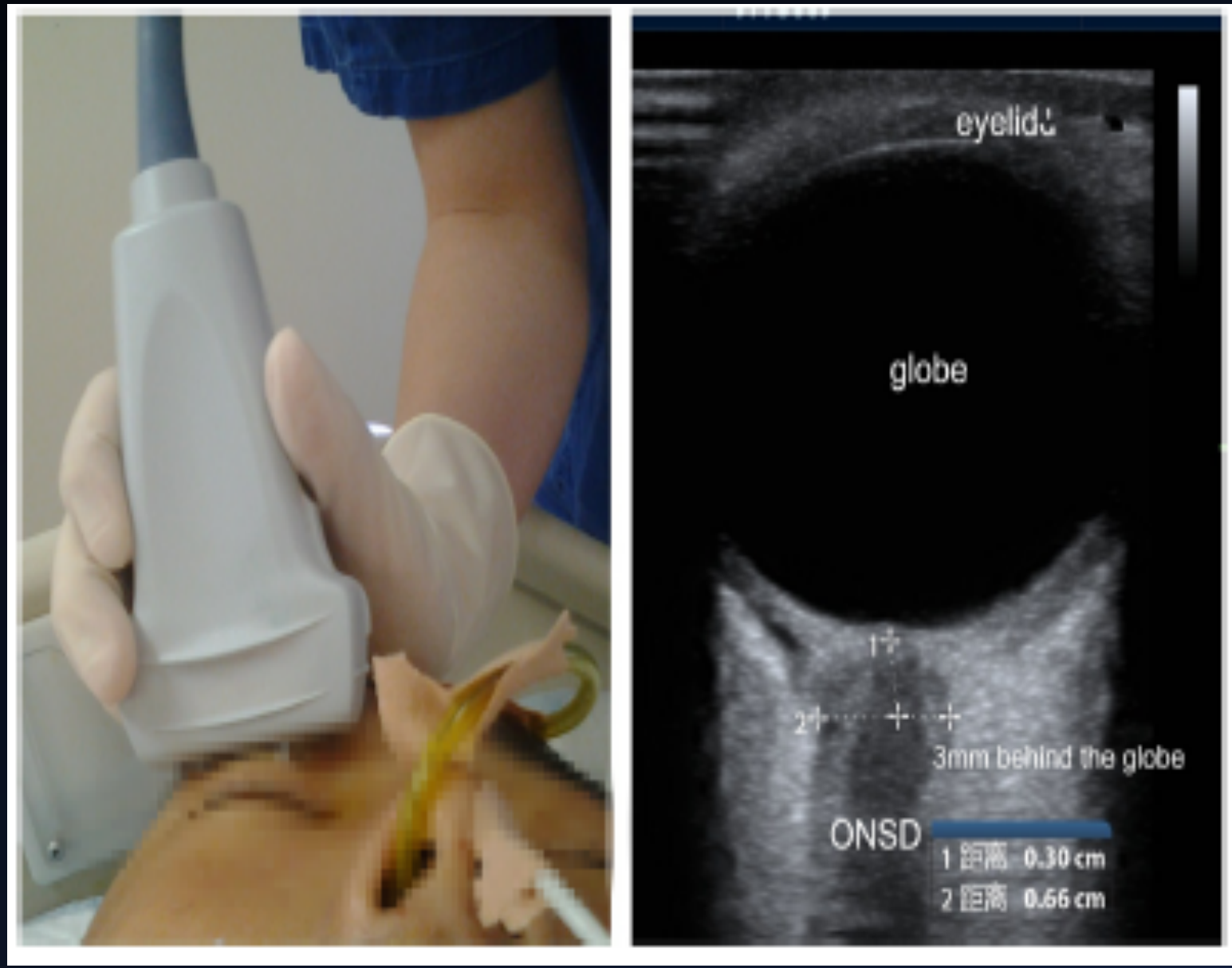
- Acute Crit Care. 2019 Feb 28;34(1):71–78.

A Trial of Intracranial-Pressure Monitoring in Traumatic Brain Injury

N ENGL J MED 367;26 NEJM.ORG DECEMBER 27, 2012



- TCD ± 15mmHg
- ONSD
  - USG
  - CT

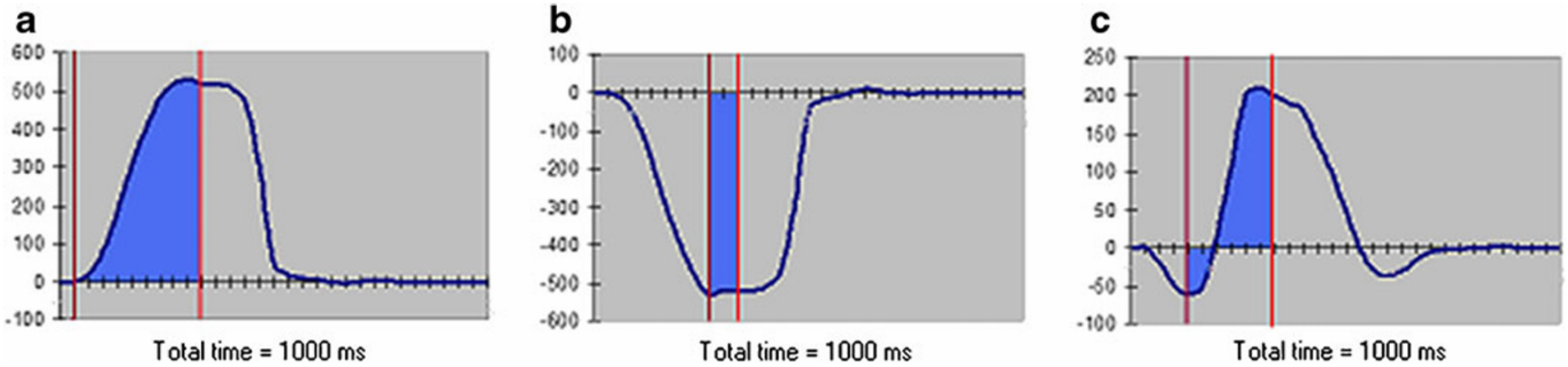


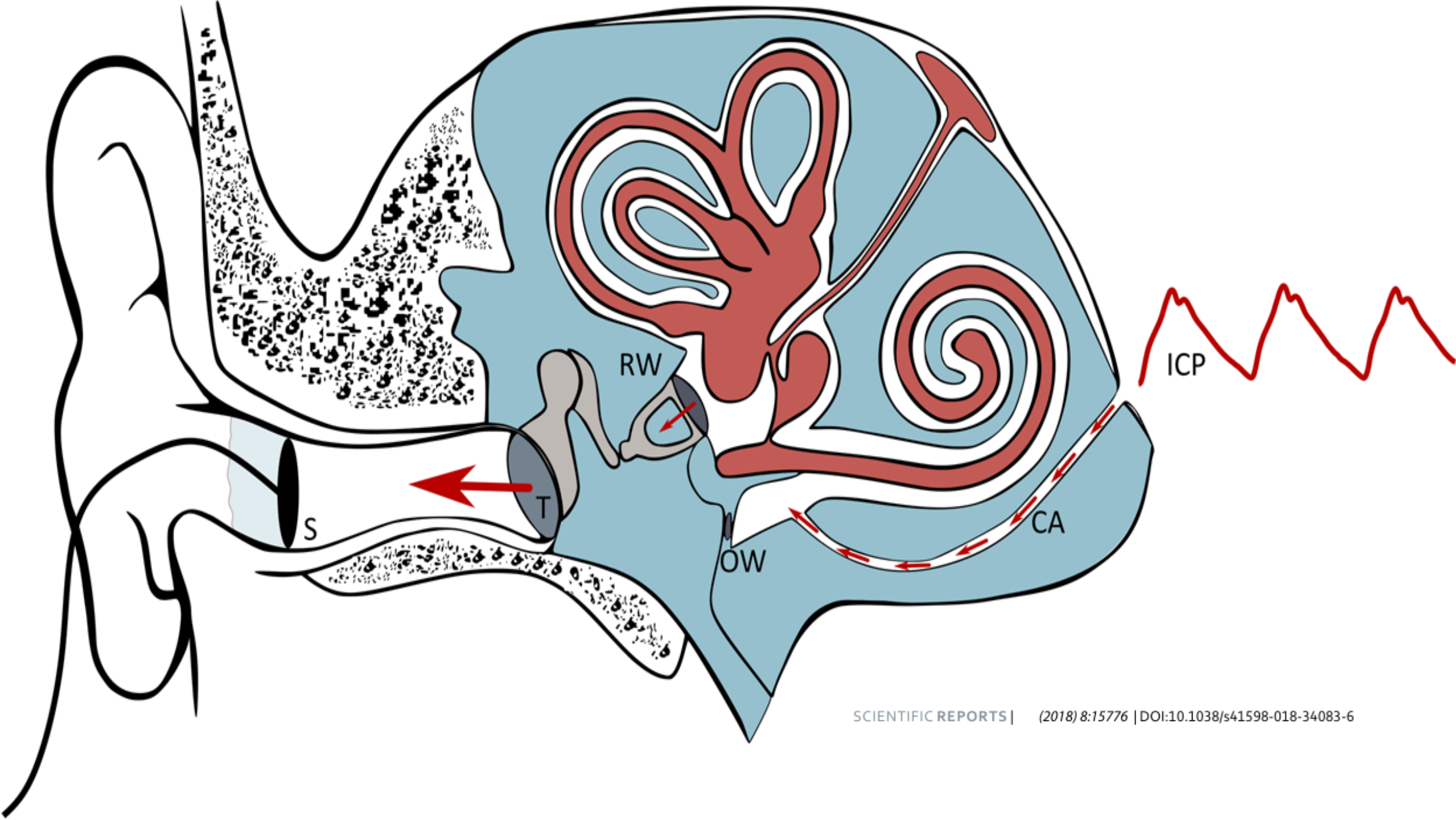
Volume 88: Issue 6 (Jun 1998)

Journal of Neurosurgery

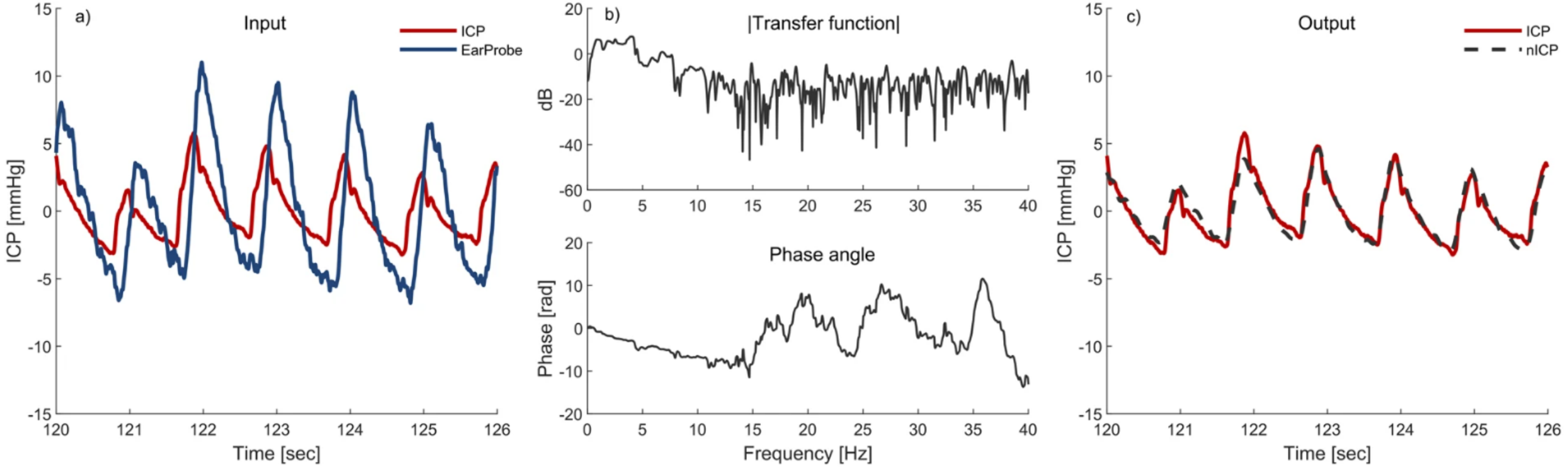
Conclusions. The TMD test can be used on a regular basis as a reproducible investigative tool in the assessment of ICP in children with shunted hydrocephalus, thereby reducing the need for invasive ICP monitoring. The equipment necessary to perform this testing is mobile. It will provide a useful serial guide to ICP abnormalities in children with shunted hydrocephalus.

The tympanic membrane displacement analyser for monitoring intracranial pressure in child Childs Nerv Syst (2013) 29:927–933





SCIENTIFIC REPORTS | (2018) 8:15776 | DOI:10.1038/s41598-018-34083-6

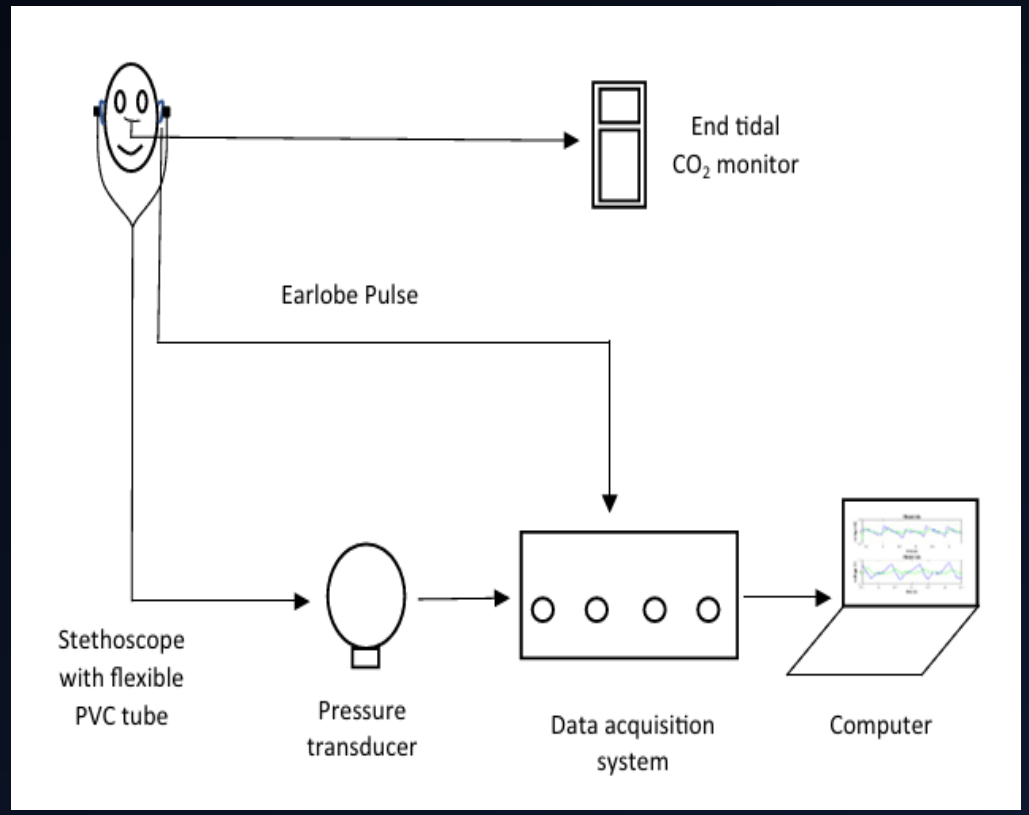


Conclusion

This study showed that the TMP waveforms measured in the outer ear could not be used to correctly predict the ICP waveform parameter MWA non-invasively. An estimate that might possibly be acceptable in clinic was only observed in 4/28 (14%) individuals. An observation of the study was that the cochlear aqueduct worked as a physical lowpass filter. This reduced the TMP measurement's ability to reproduce the entire spectral content of the ICP waveform, and hence affected the MWA estimation.

Noninvasive detection of elevated ICP using spontaneous tympanic membrane pulsation

Scientific Reports | (2021) 11:21957 |

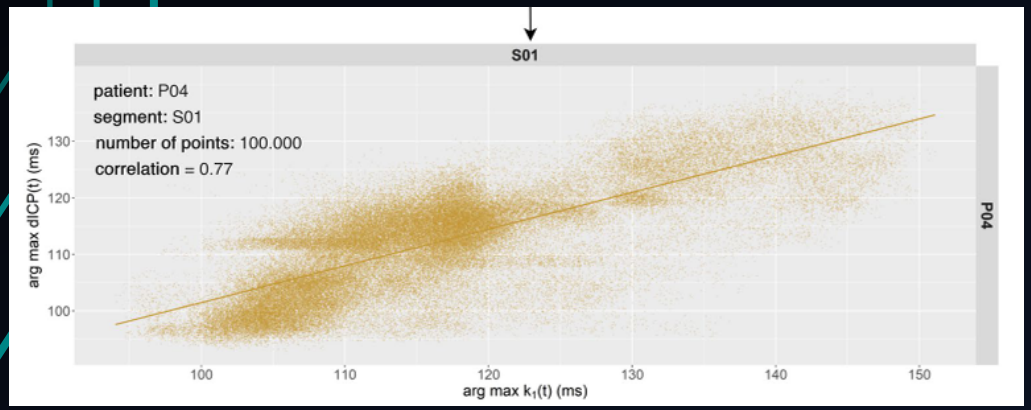


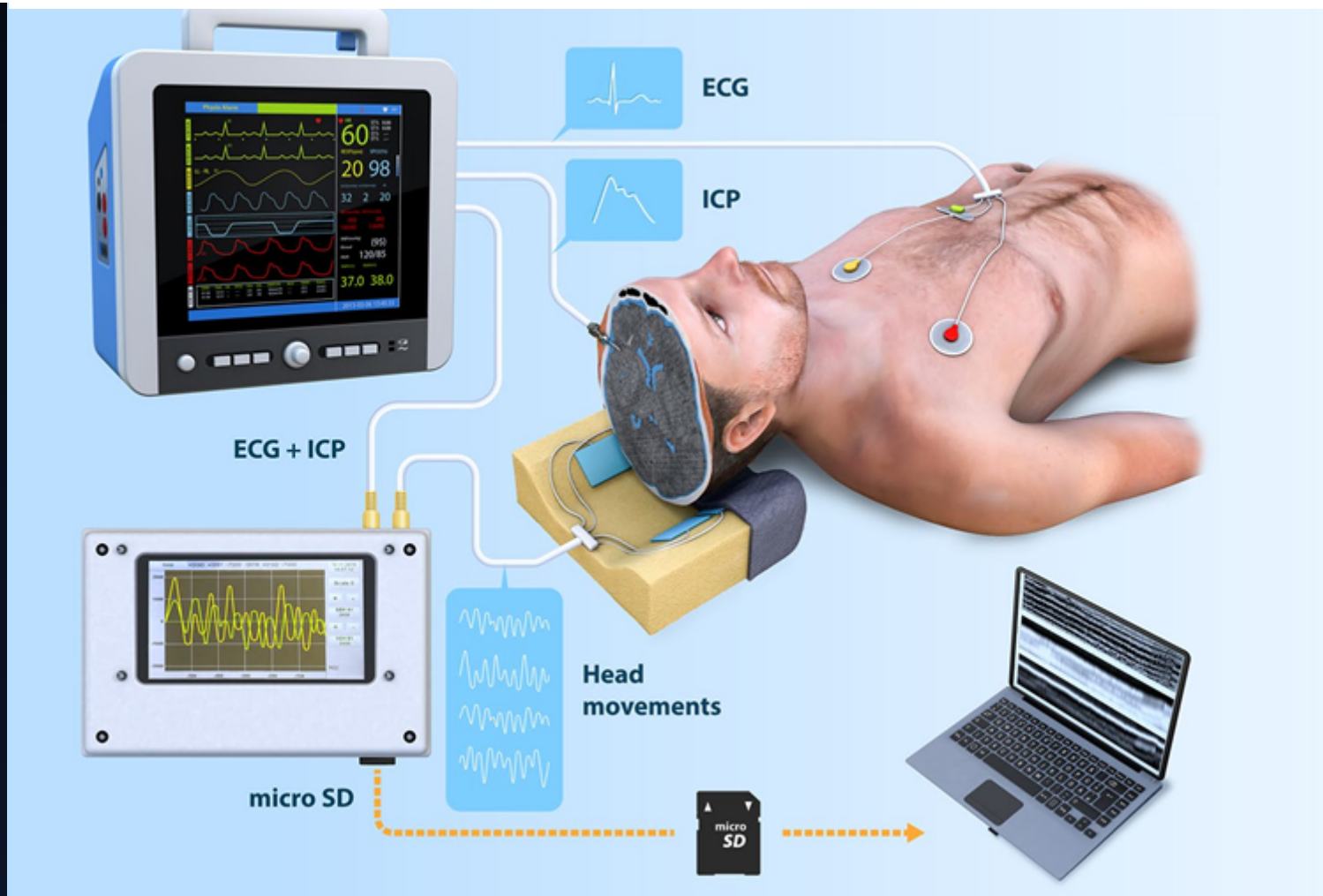
The study results are encouraging as they may result in a relatively simple, noninvasive diagnostic technique to detect ICP elevation. More studies are needed to confirm the generality of these results in a larger number of subjects, including patients with (or at risk of) elevated ICP.

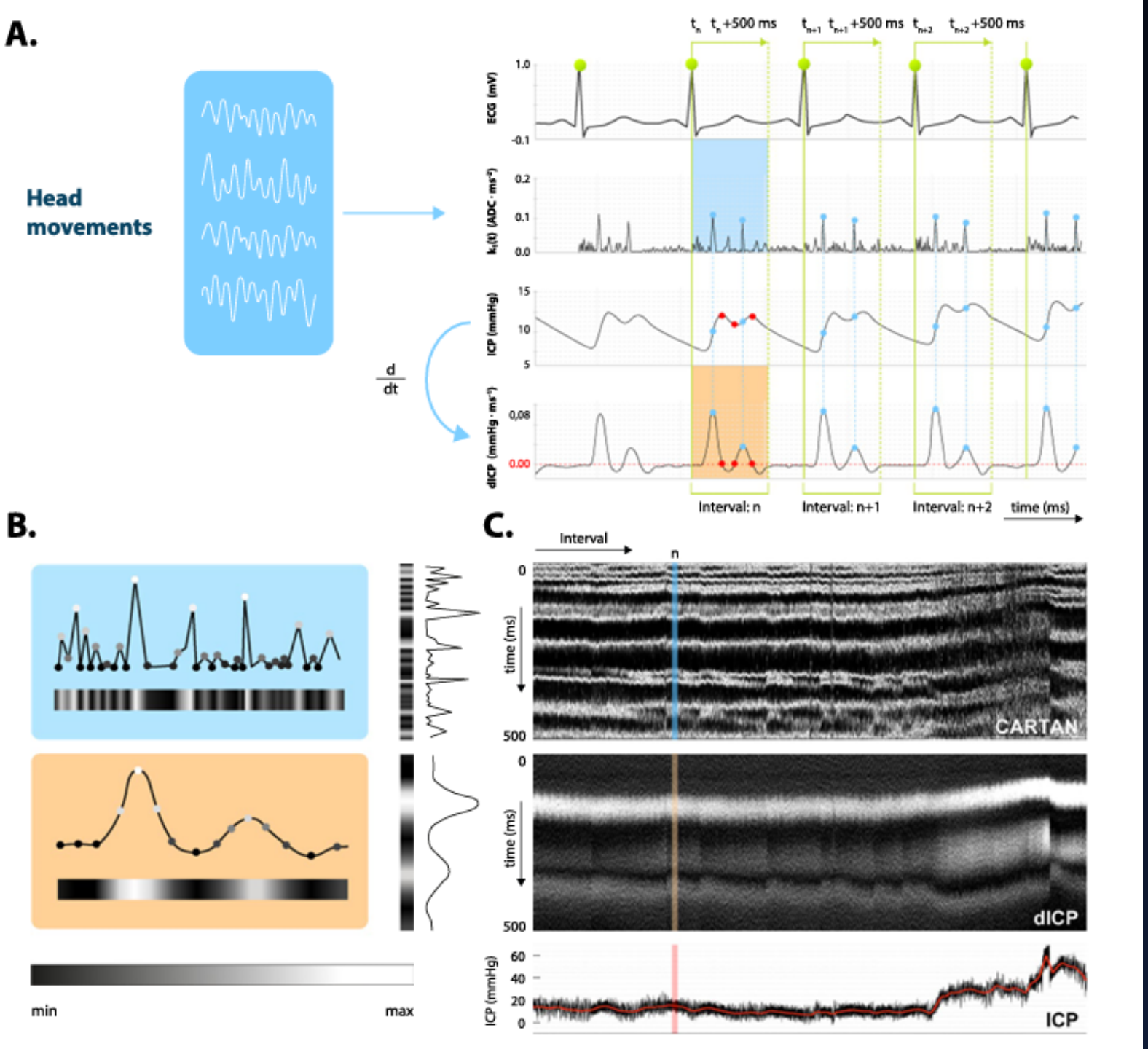
From head micro-motions towards CSF dynamics and non-invasive intracranial pressure monitoring

Arnošt Mládek[1,2], Václav Gerla[2], Petr Šeba[3], Vladimír Kolář[4], Petr Skalický[1,5], Helen Whitley[1], Lenka Lhotská[2,6], Vladimír Beneš[1] & Ondřej Bradáč[1,5]✉

Scientific Reports | (2021) 11:14349

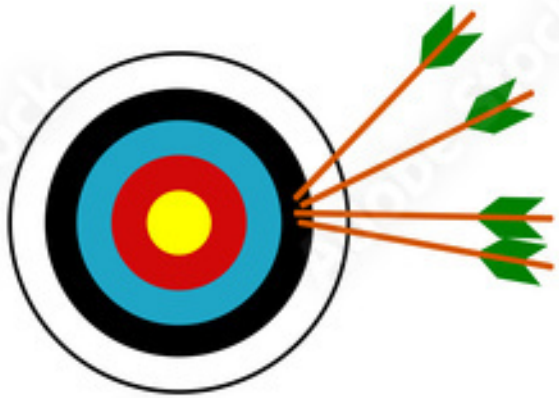





A.
Head movements
d/dt
ECG (mV)
ICP (mmHg)
dICP (mmHg · ms⁻¹)
Interval: n
Interval: n+1
Interval: n+2
time (ms)
B.
min
max
C.
Interval
n
time (ms)
CARTAN
dICP
ICP (mmHg)
ICP



High Accuracy



High Precision



& High Accuracy
High Precision

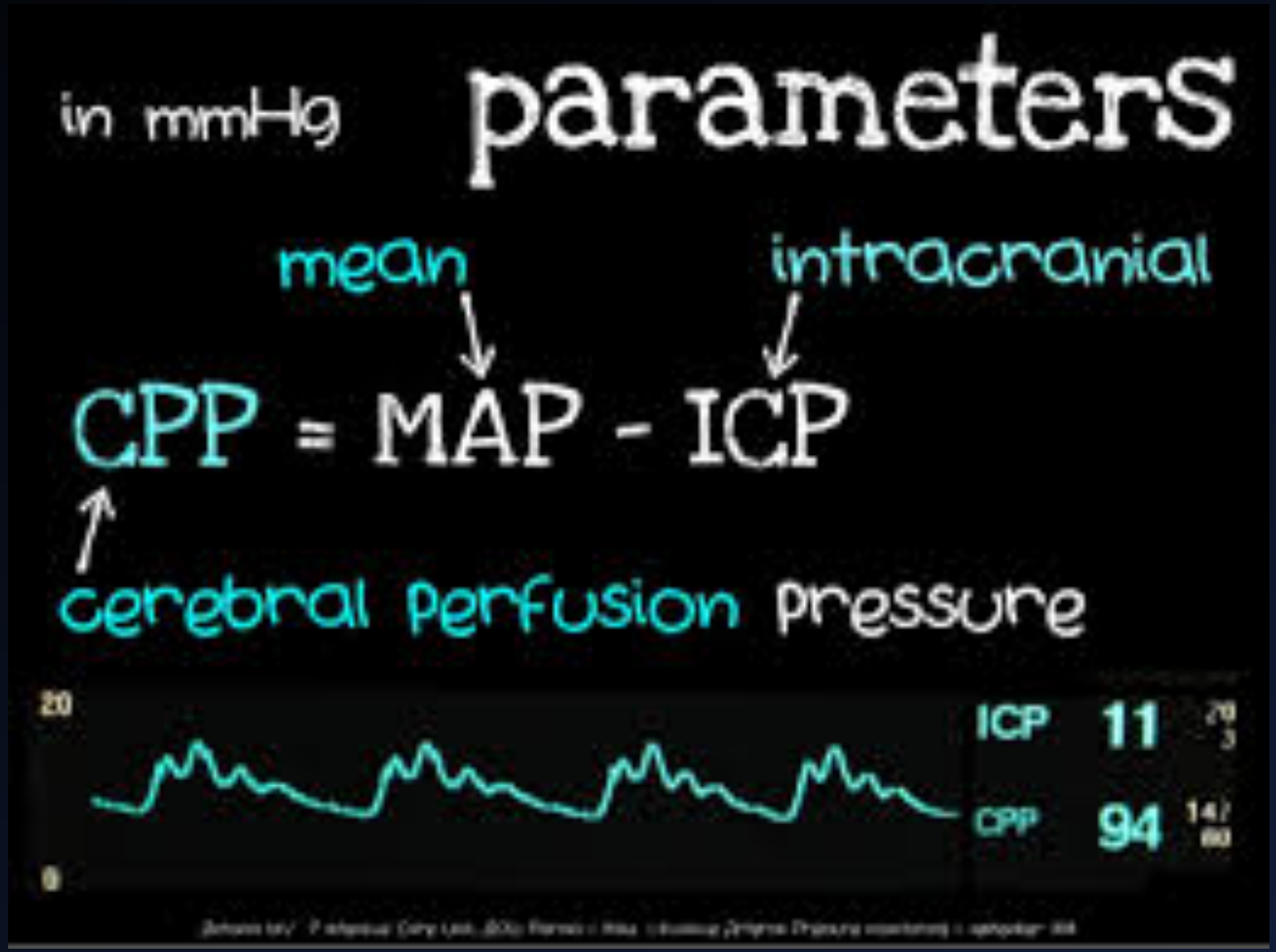


& Low Accuracy
Low Precision

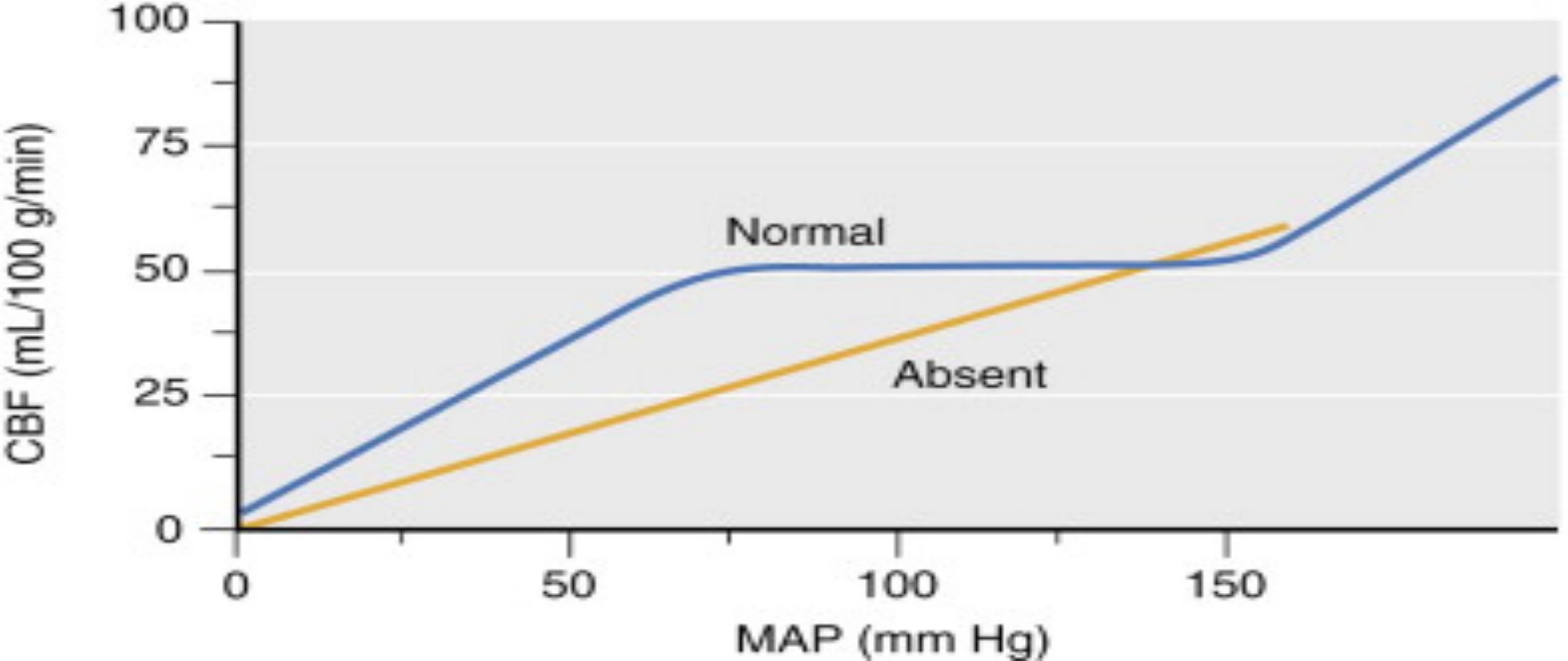
Adobe Stock | #308832180

CPP

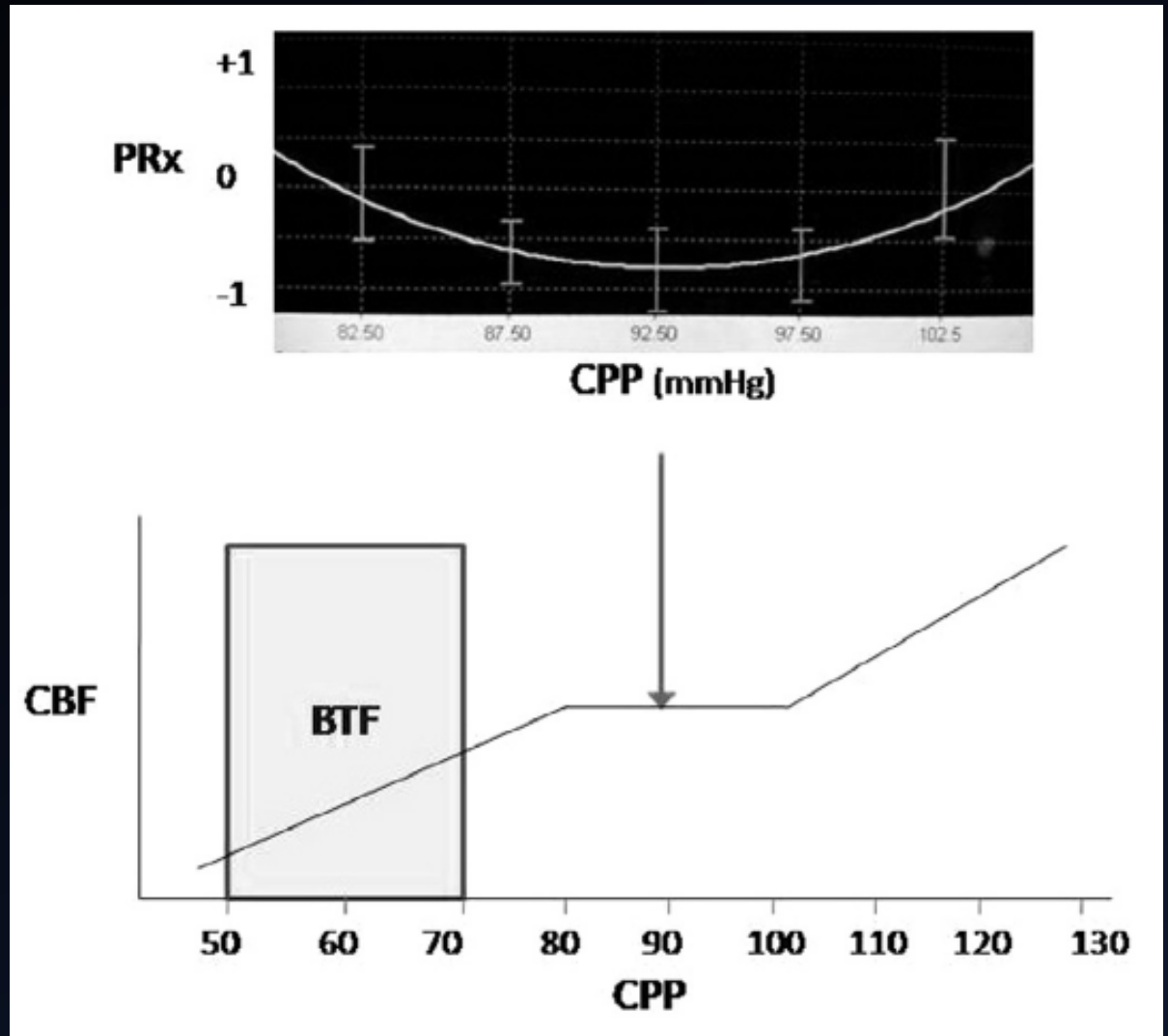
- -0-

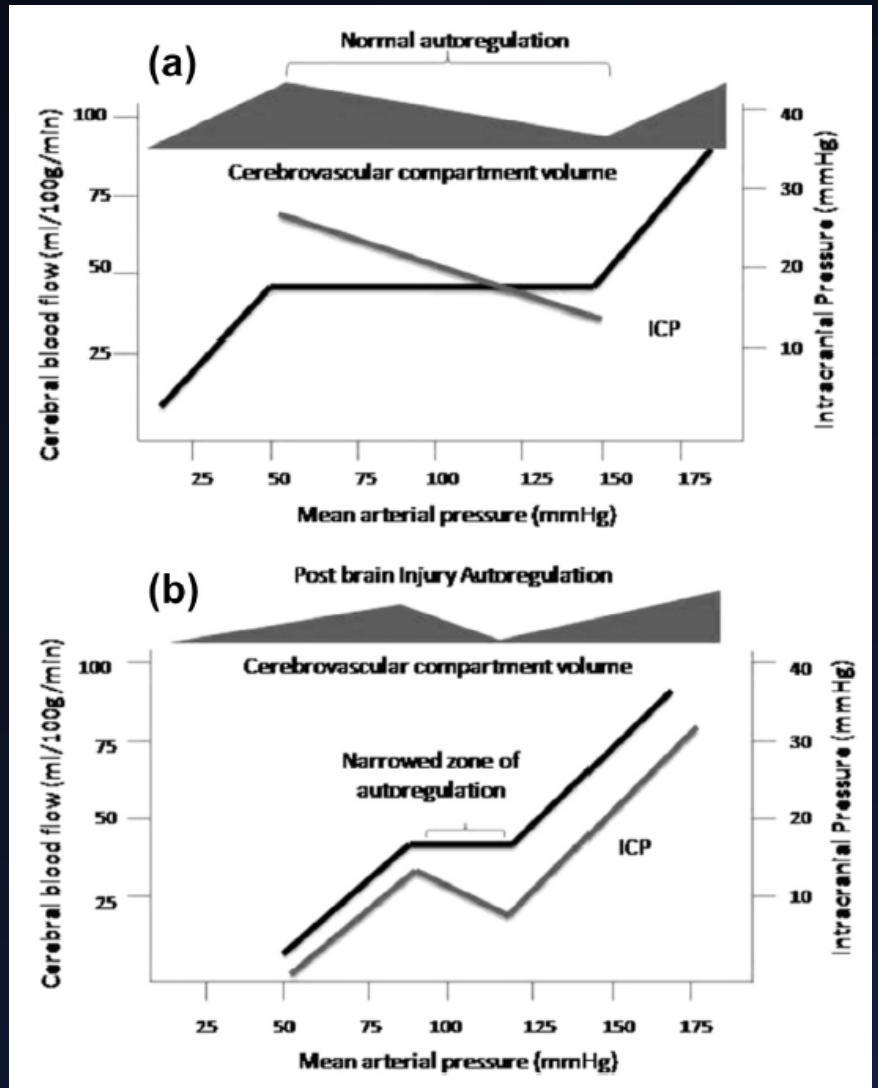

in mmHg
parameters
mean
intracranial
CPP = MAP - ICP
cerebral perfusion pressure
20
0
ICP
11
CPP
94

Autoregulace

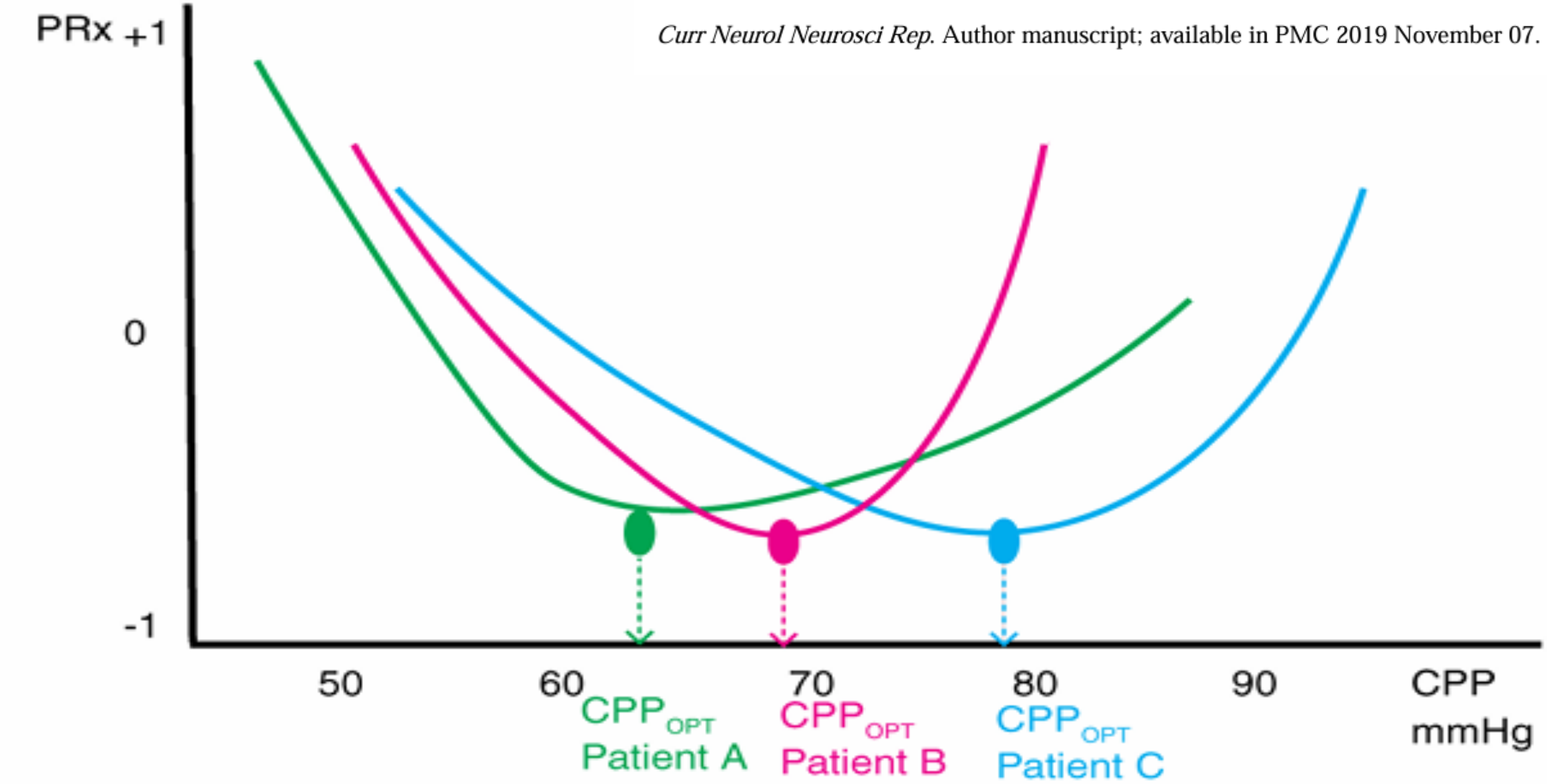


„Further prospective, randomized controlled studies should be undertaken to clarify its role in the acute management of TBI.“



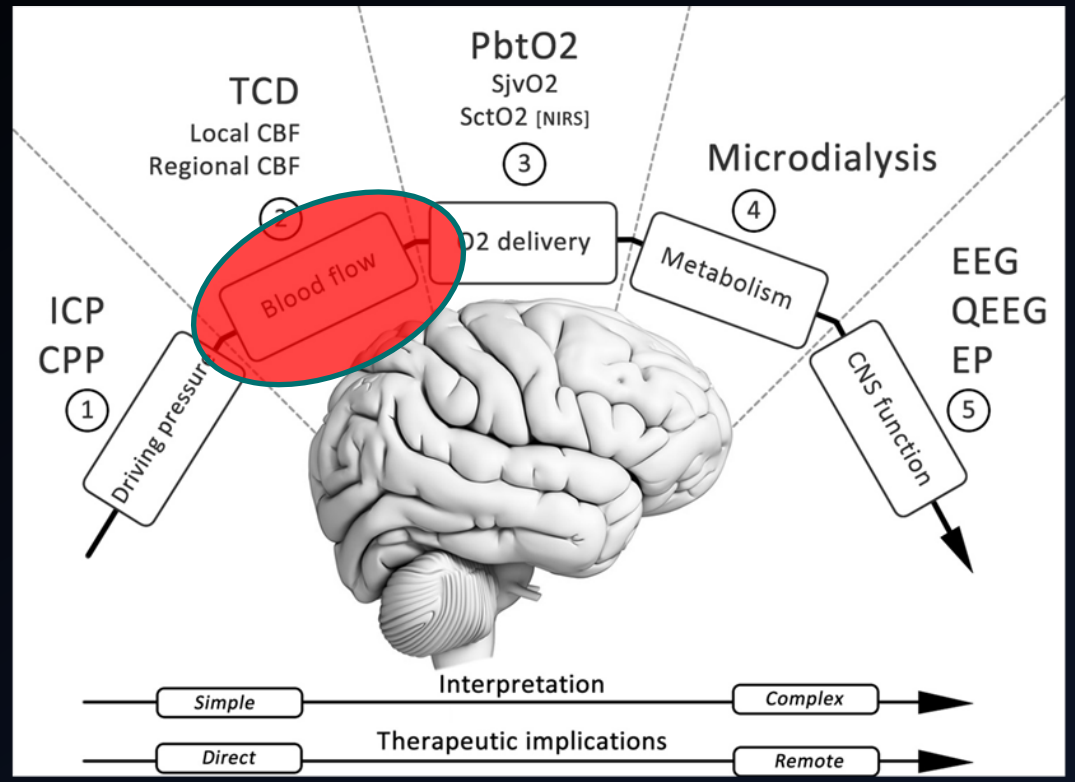


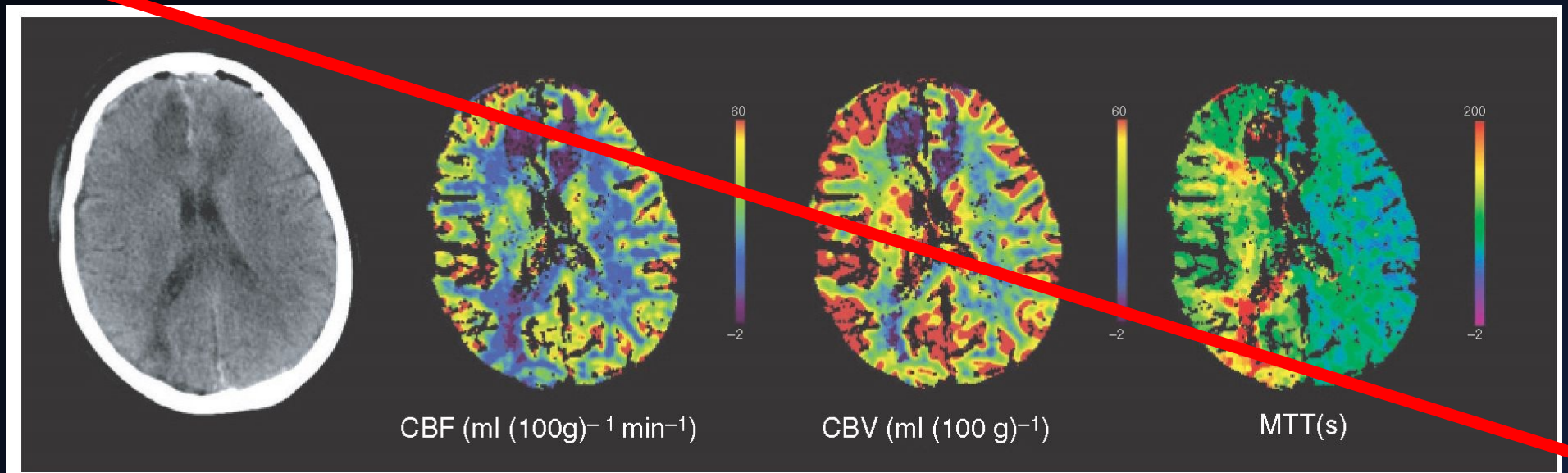
Curr Neurol Neurosci Rep. Author manuscript; available in PMC 2019 November 07.



II. Průtok

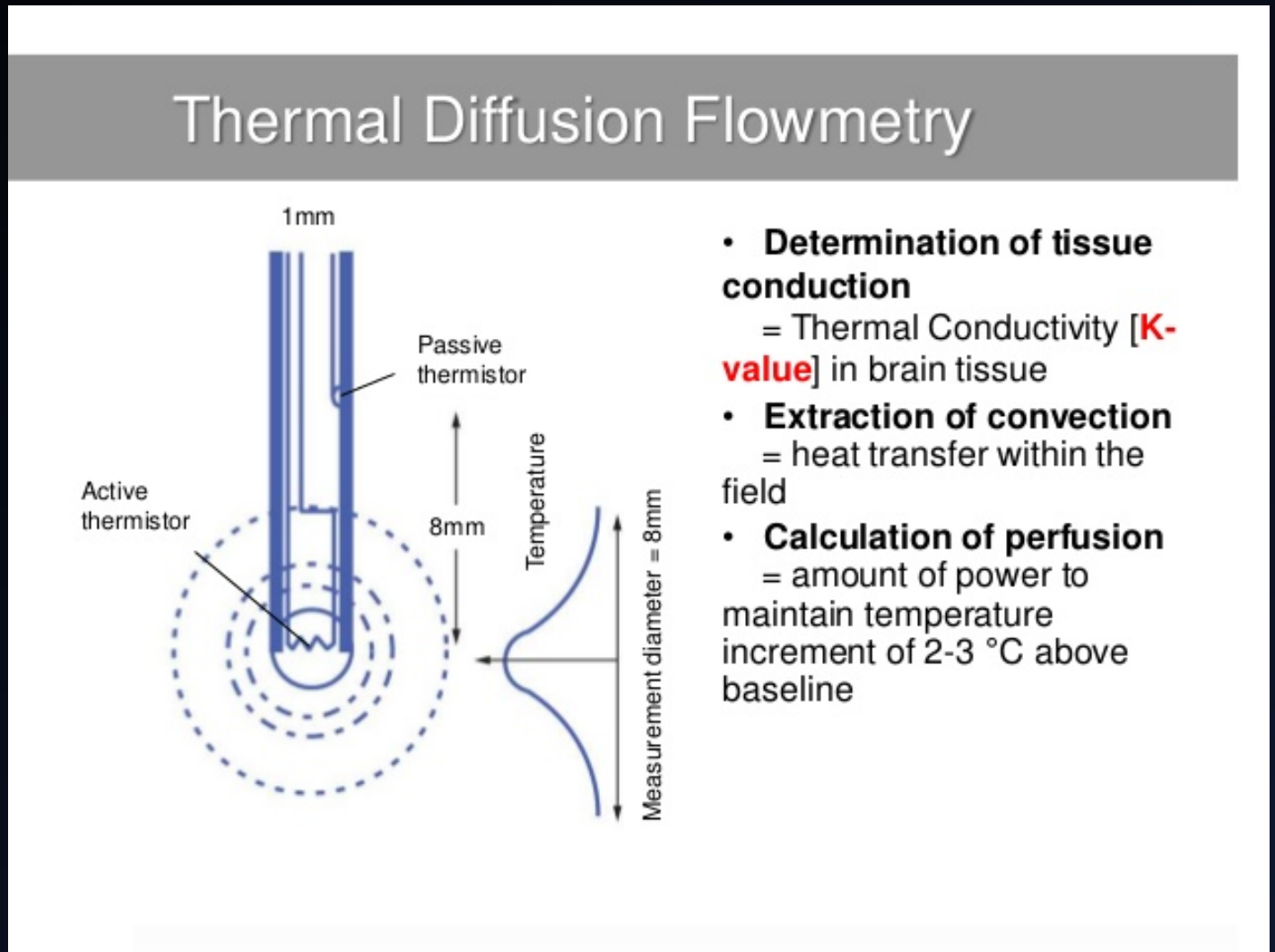
- Regionální
- Lokální





Thermal Diffusion Flowmetry

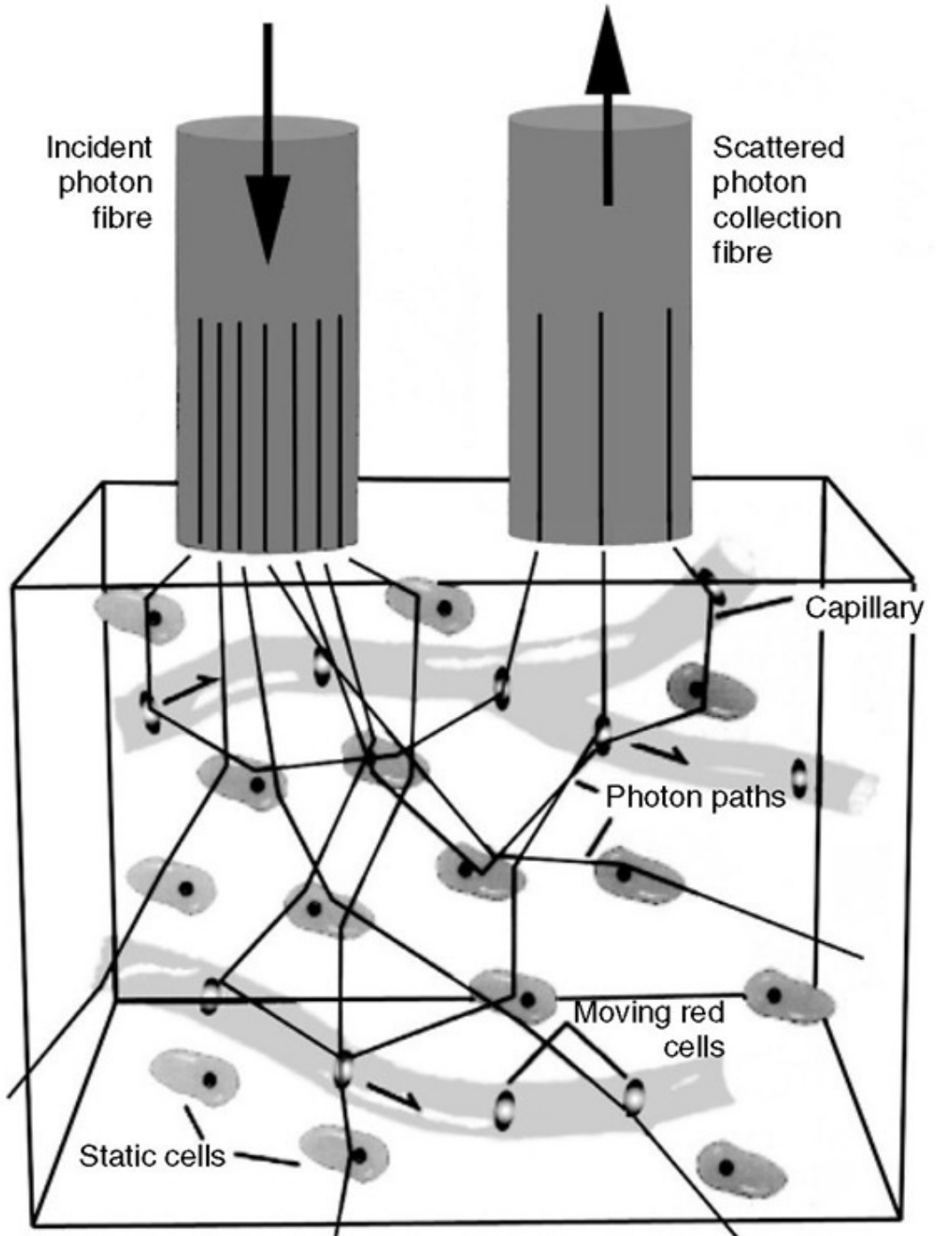
larger trials are needed to confirm



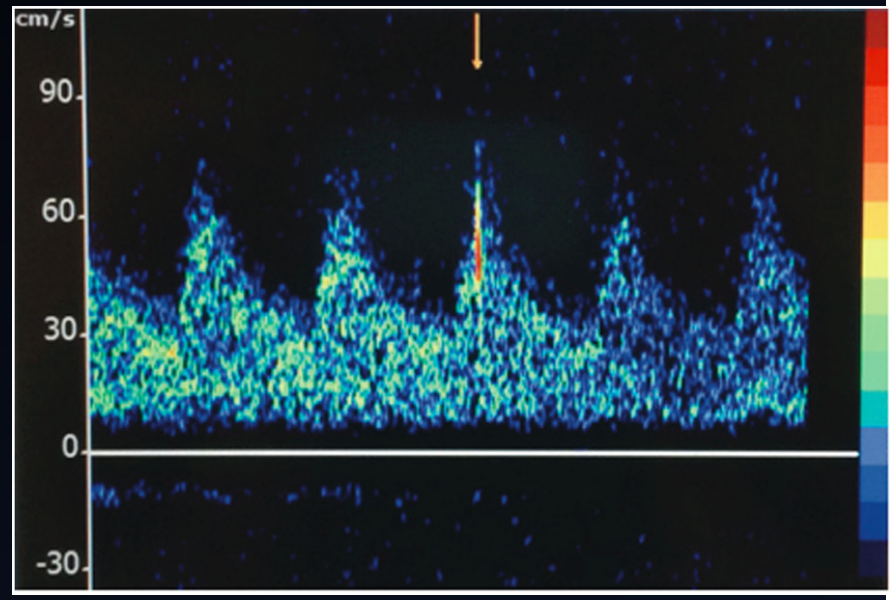


Laser

- Lokální
- 1mm^3
- experiment



TCD



- Rychlost
- Pulsatilita

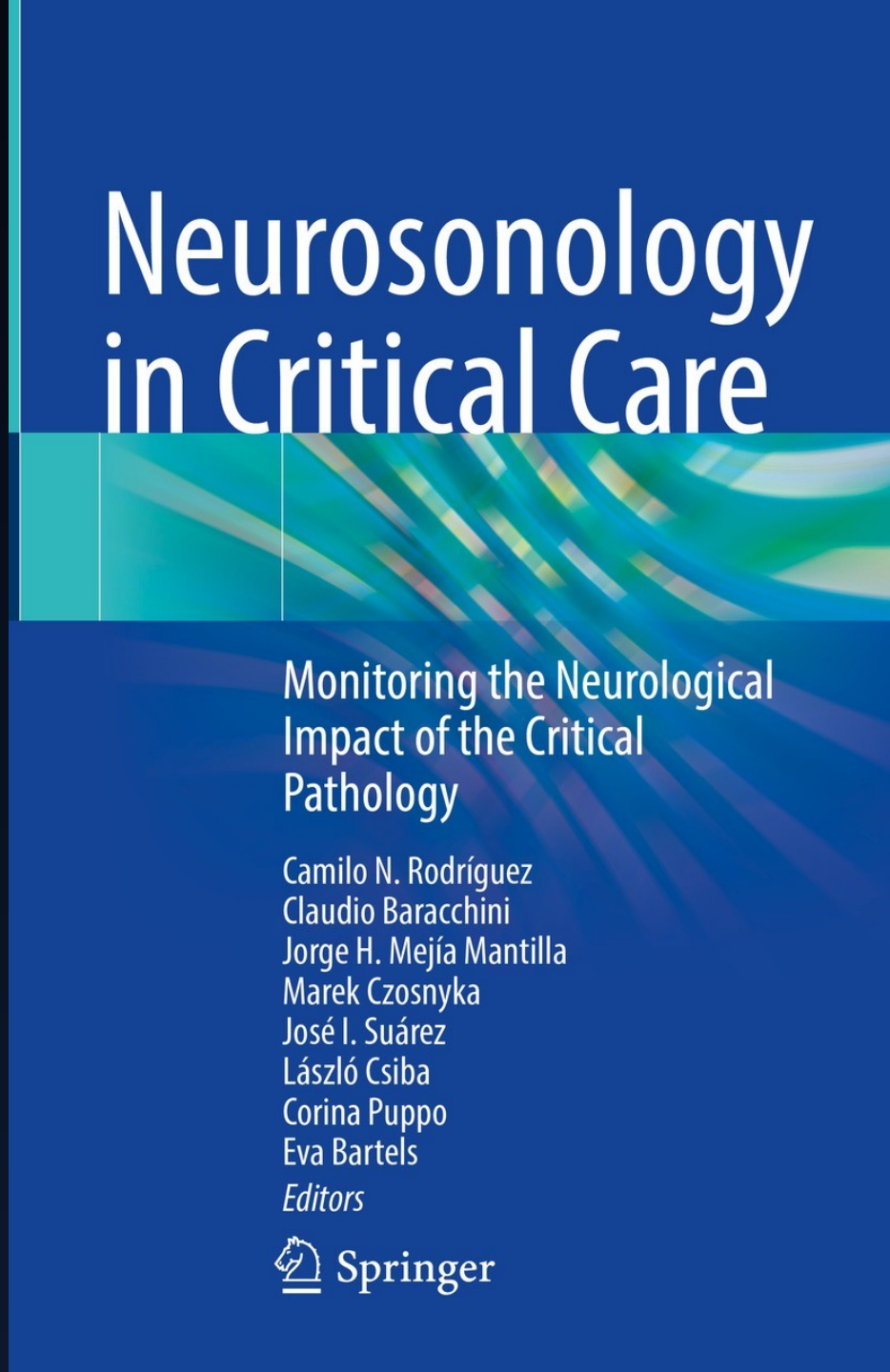
- CBF
- Reaktivita CO_2
- Terapeutické intervence



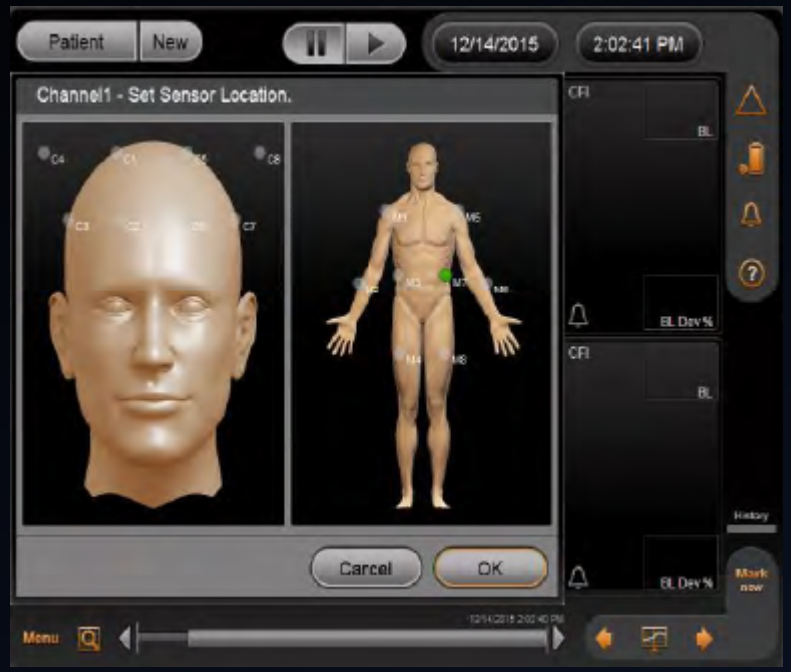
- SAK
- Mozková smrt

?

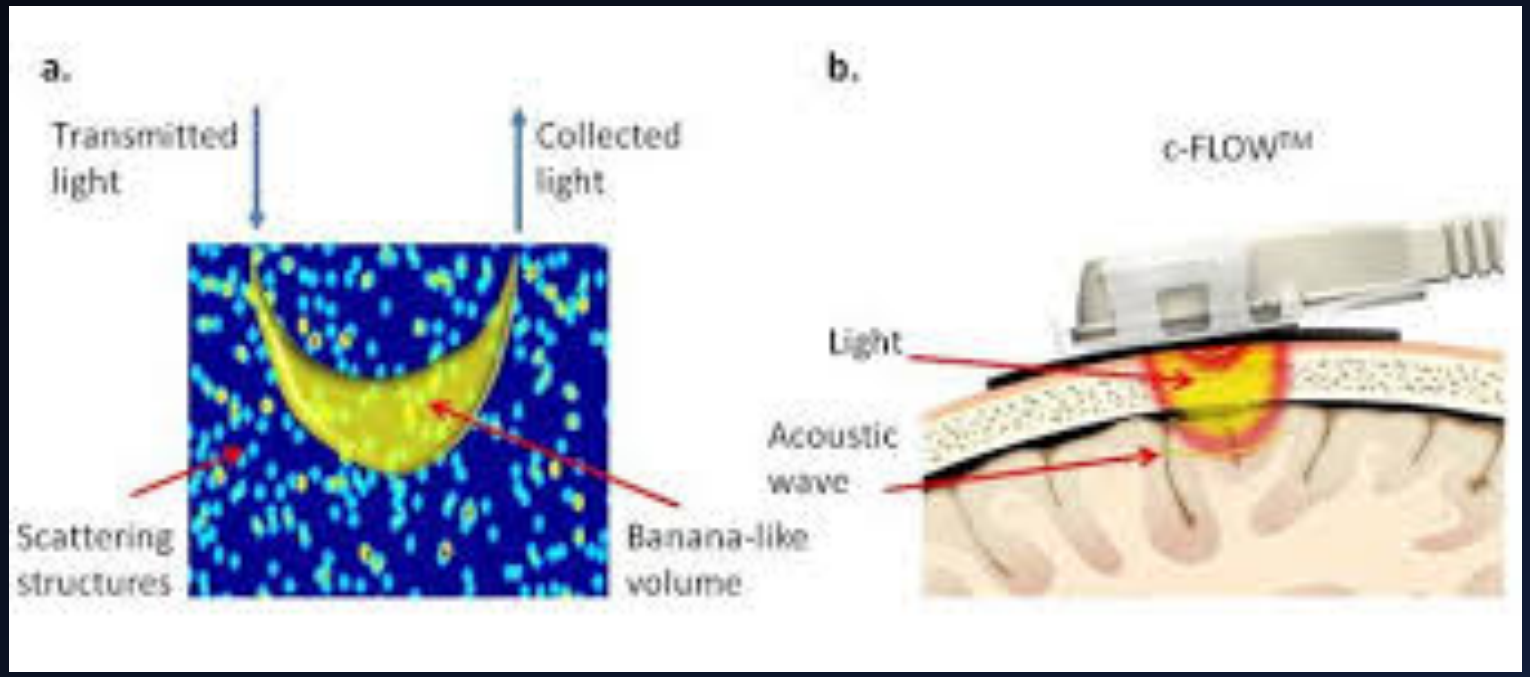
- Jak často
- Vyšetřující
- Vyšetřovaný



C flow

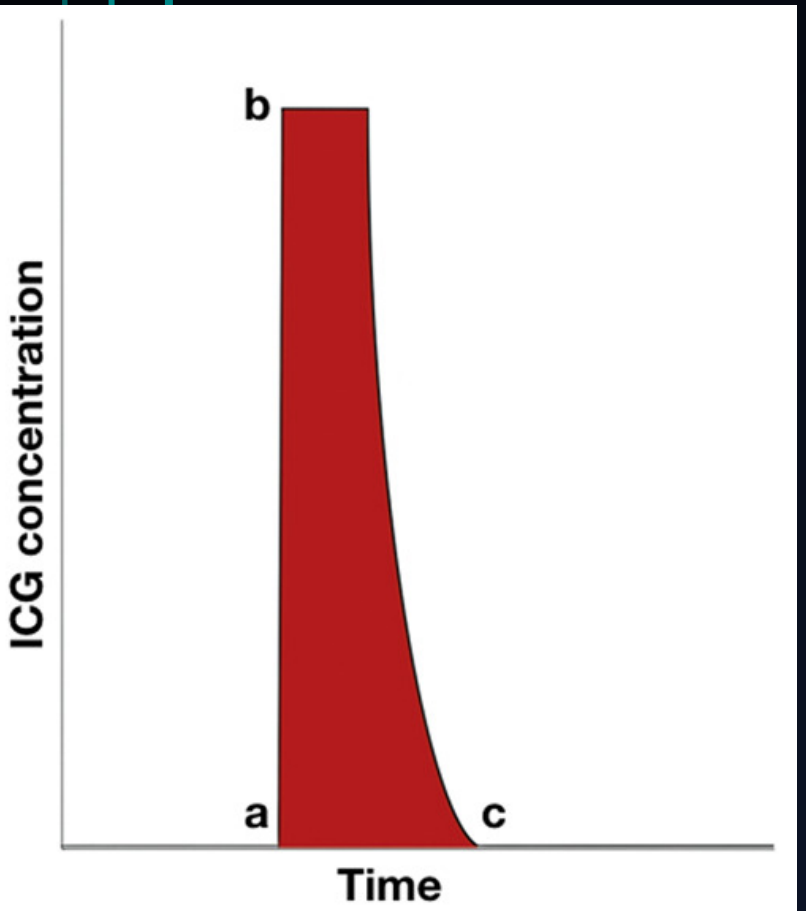

Patient
New
12/14/2015
2:02:41 PM
Channel1 - Set Sensor Location.
Cancel
OK
Menu

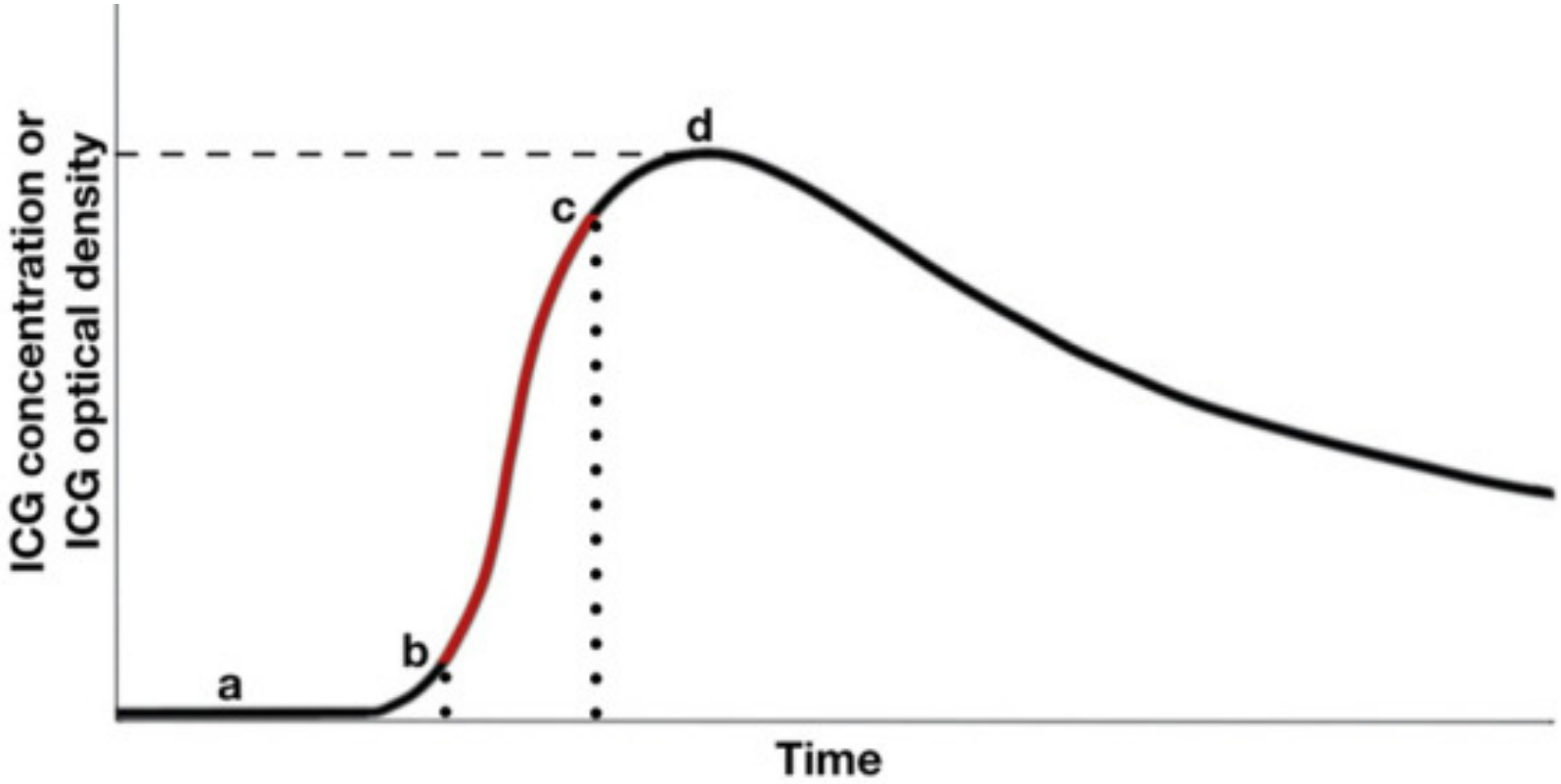


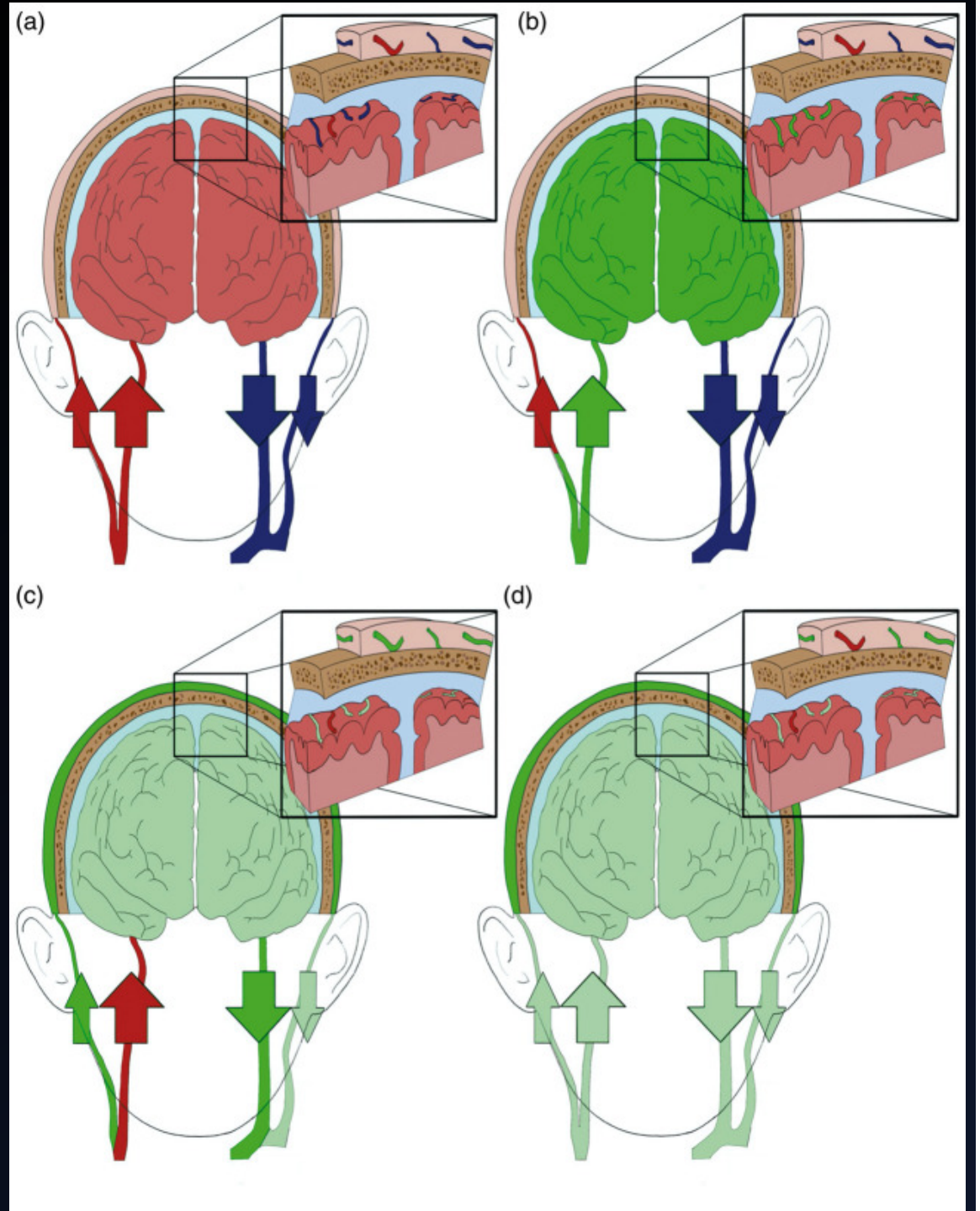

a.
Transmitted light
Collected light
Scattering structures
Banana-like volume
b.
c-FLOW™
Light
Acoustic wave

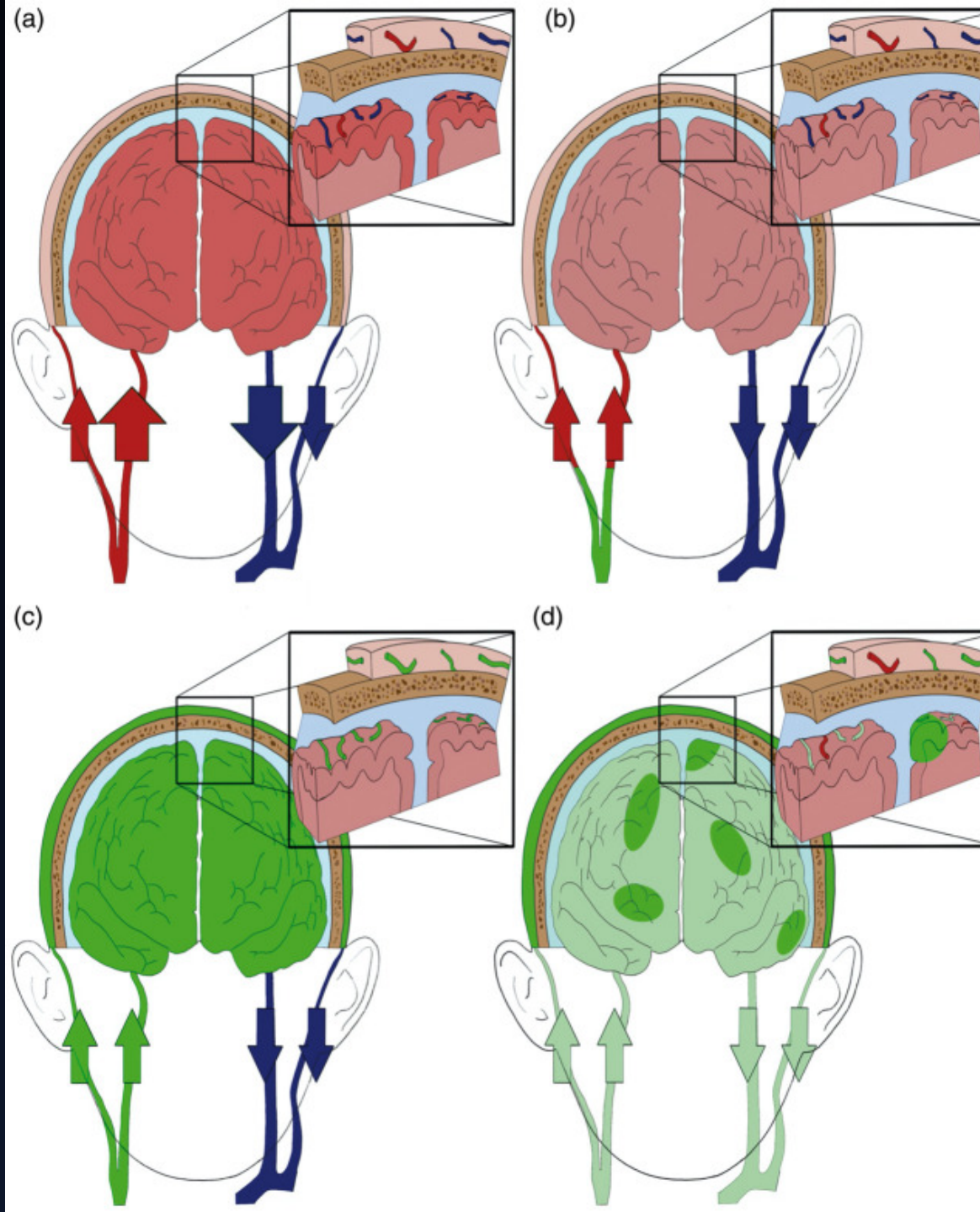
Cerebral perfusion and blood–brain barrier assessment in brain trauma using contrast-enhanced near-infrared spectroscopy with indocyanine green: A review

Journal of Cerebral Blood Flow & Metabolism
2020, Vol. 40(8) 1586–1598





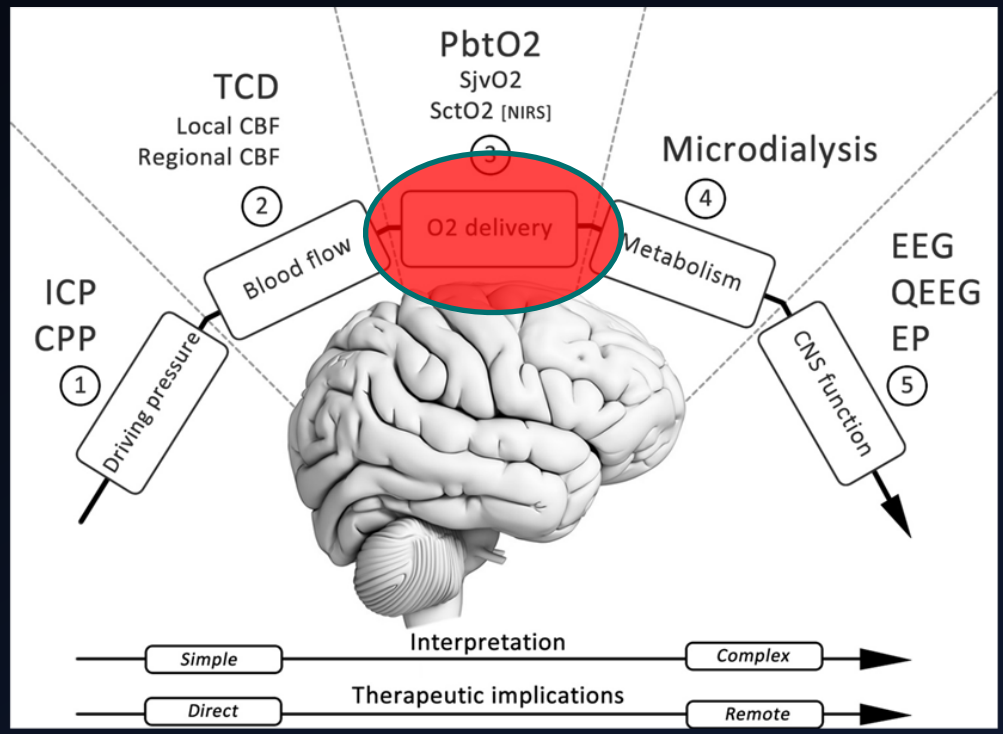

(a)
(b)
(c)
(d)


(a)
(b)
(c)
(d)

III. Mozková oxygenace

- Saturace v jugulárním bulbu
- Tkáňová oxymetrie

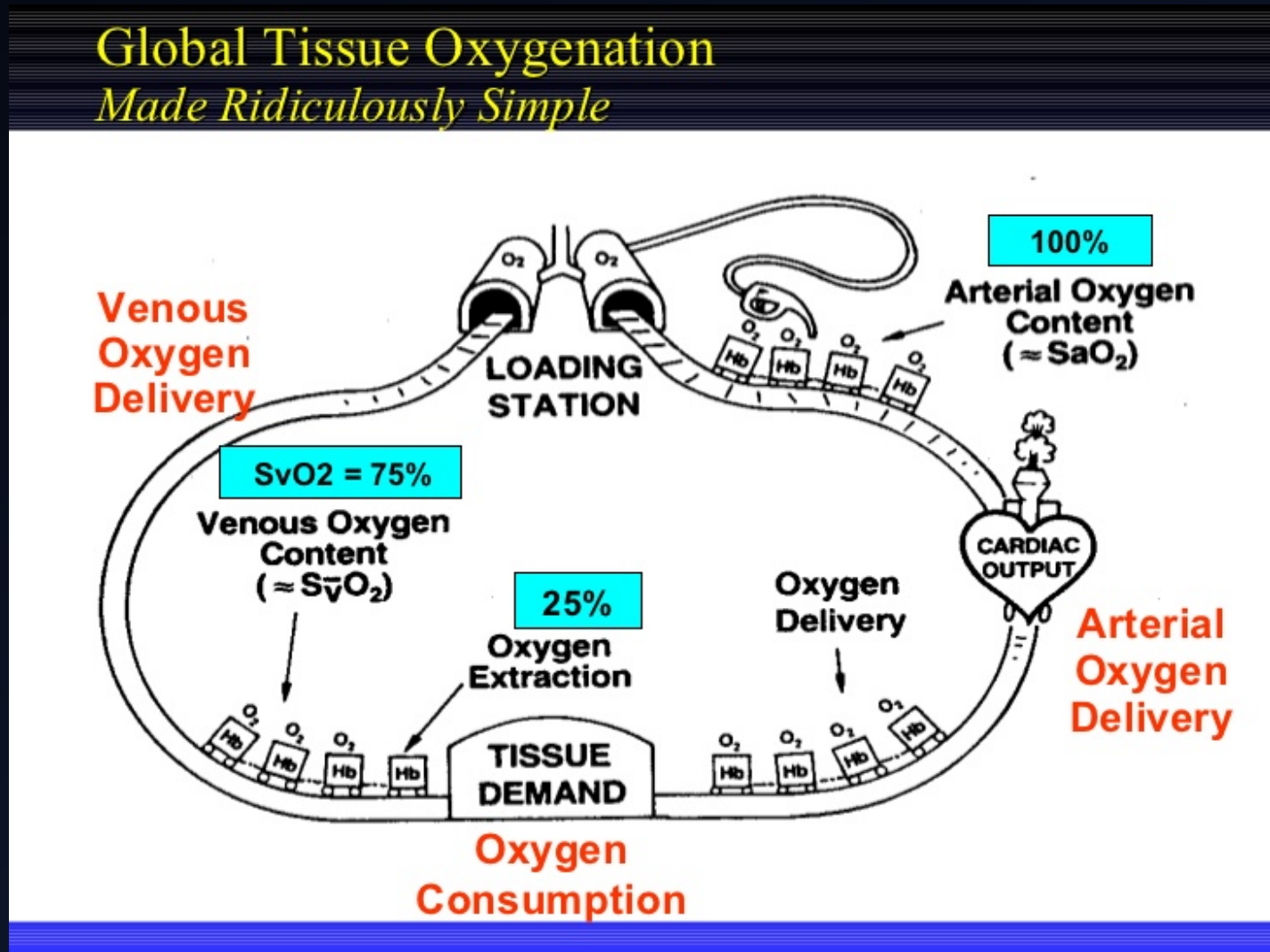
- NIRS

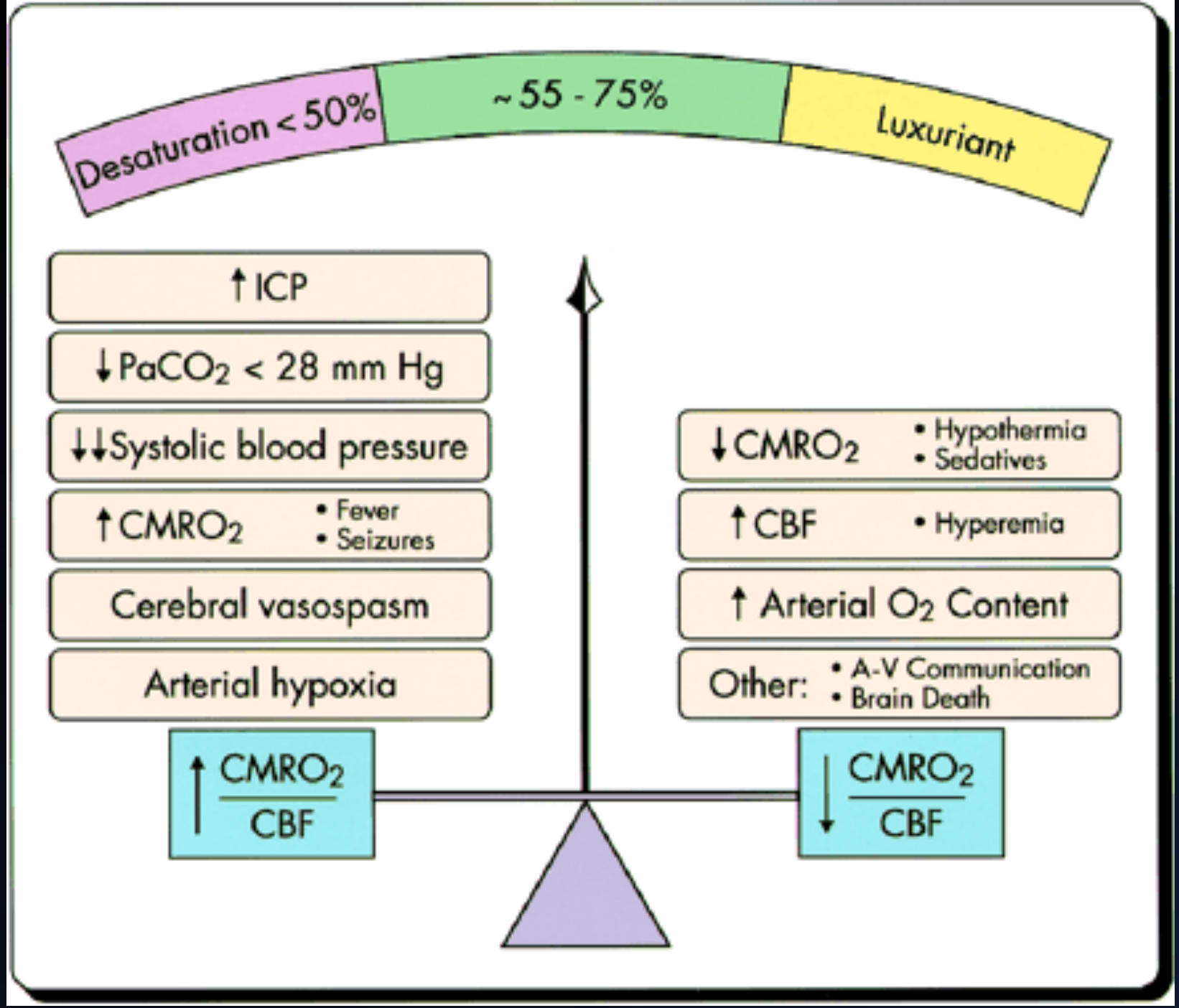


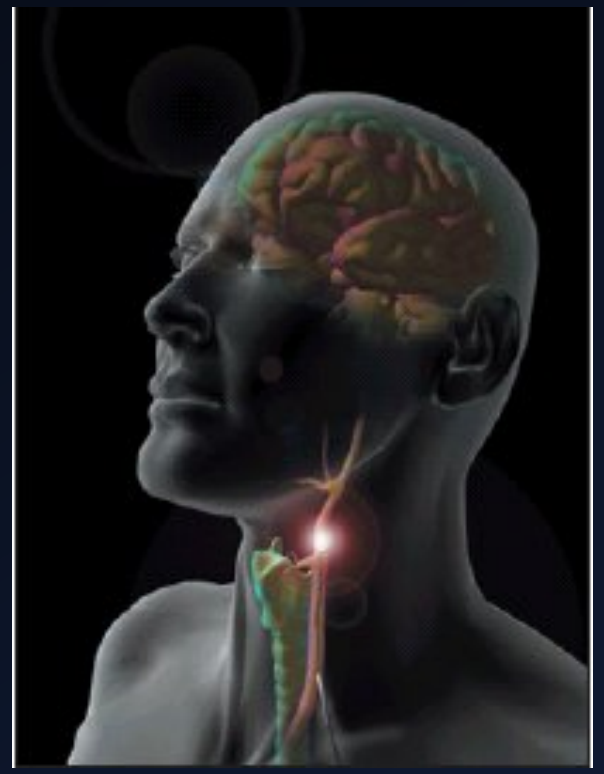
Jugulární oxymetrie – $Sv_{jb}O_2$

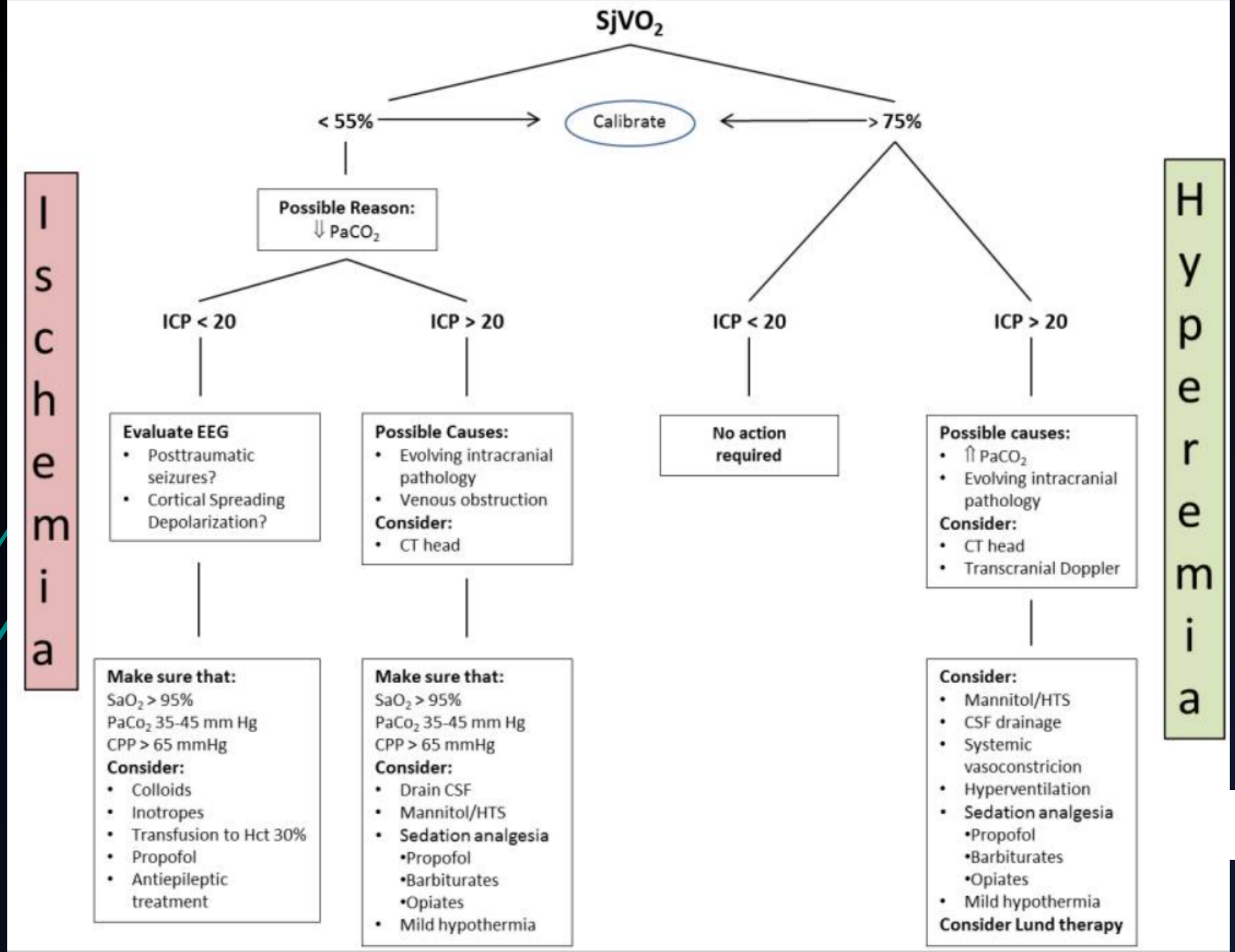
- 55-75%
- Extrakce

- Dominantní žíla 62.5%
- Korektní pozice
- > 15% tkáně




Desaturation < 50%
~ 55 - 75%
Luxuriant
↑ ICP
↓ $PaCO_2$ < 28 mm Hg
↓↓ Systolic blood pressure
↑ $CMRO_2$
• Fever
• Seizures
Cerebral vasospasm
Arterial hypoxia
↓ $CMRO_2$
• Hypothermia
• Sedatives
↑ CBF
• Hyperemia
↑ Arterial O_2 Content
Other:
• A-V Communication
• Brain Death
↑ $\frac{CMRO_2}{CBF}$
↓ $\frac{CMRO_2}{CBF}$

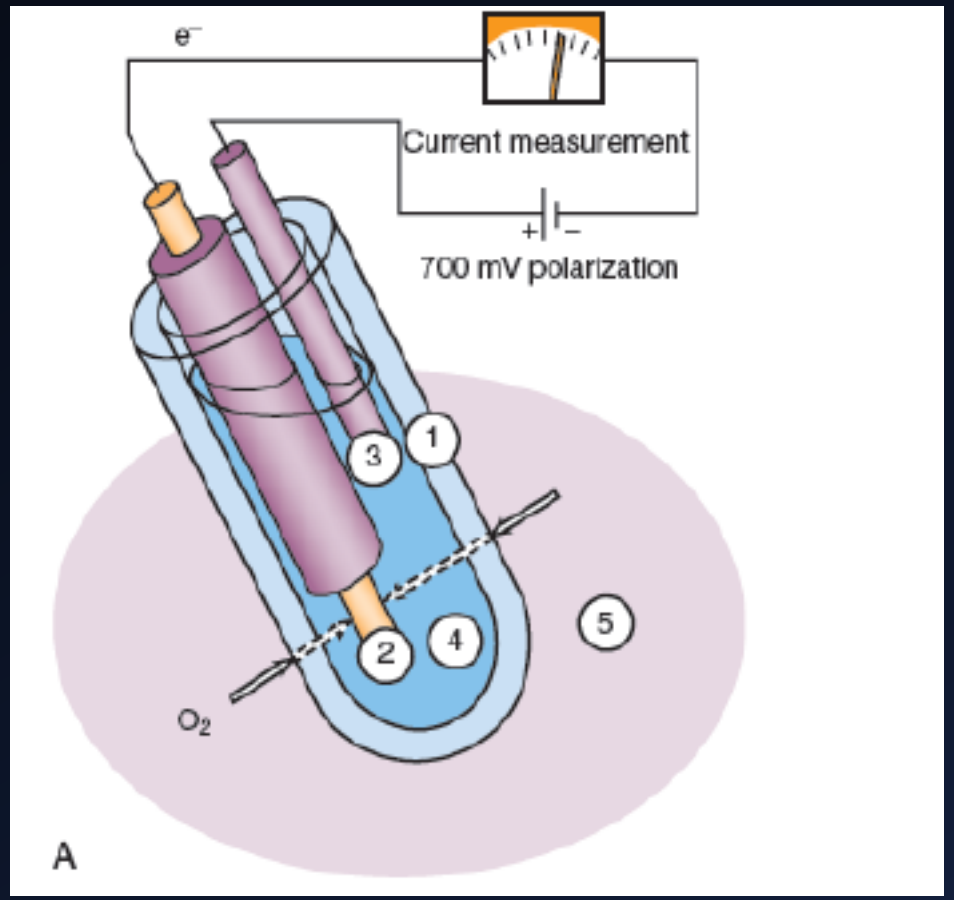




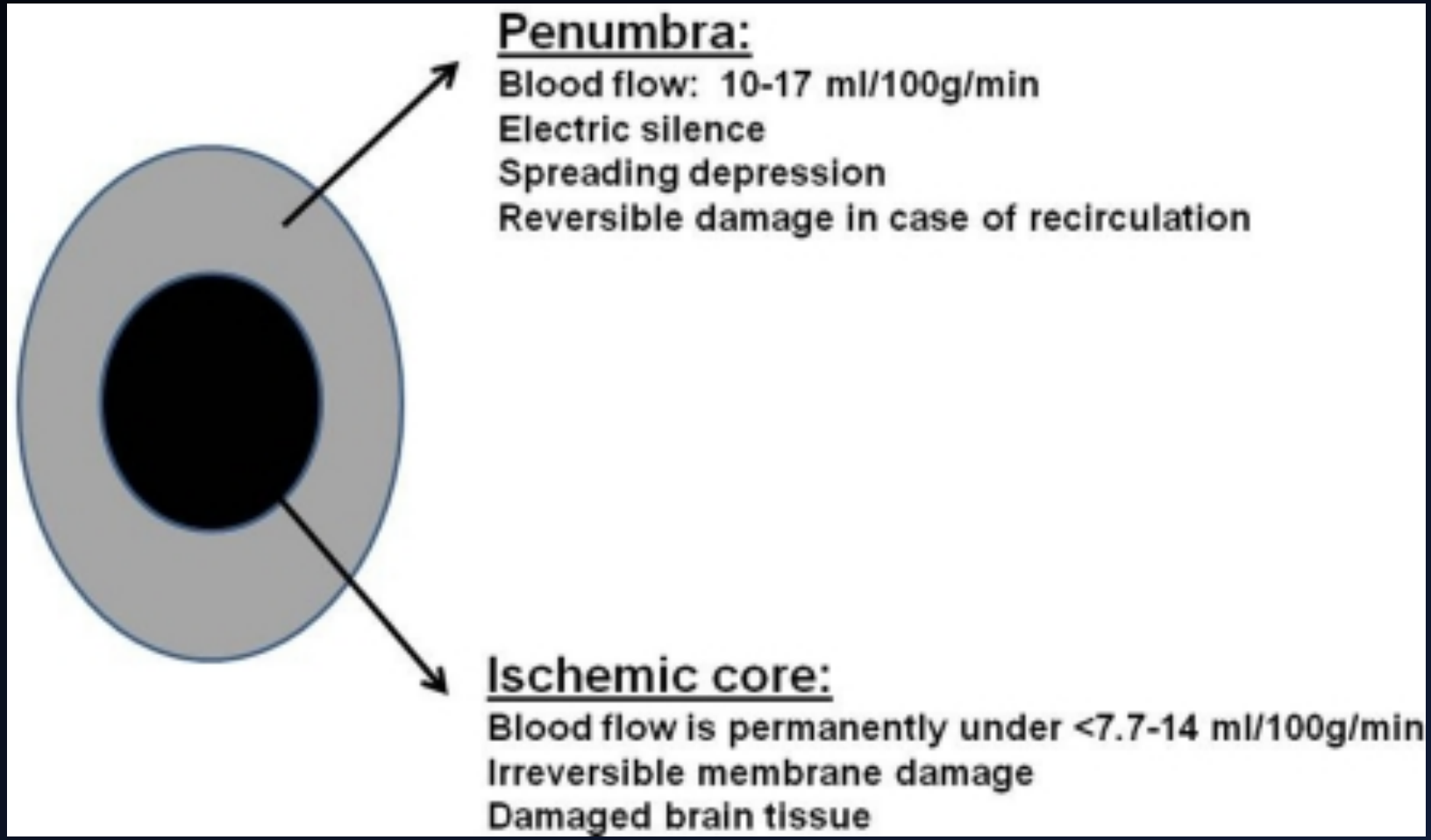
Med. Sci. **2019**, *7*, 37

Parciální tlak kyslíku v mozkové tkáni - $PbtO_2$

- 20 – 40 mmHg
- DO_2 x VO_2
  - PaO_2, $PaCO_2$, FiO_2
  - MAP, CO
  - Hb
  - ICP, CPP
  - Autoregulace, metabolismus, křeče



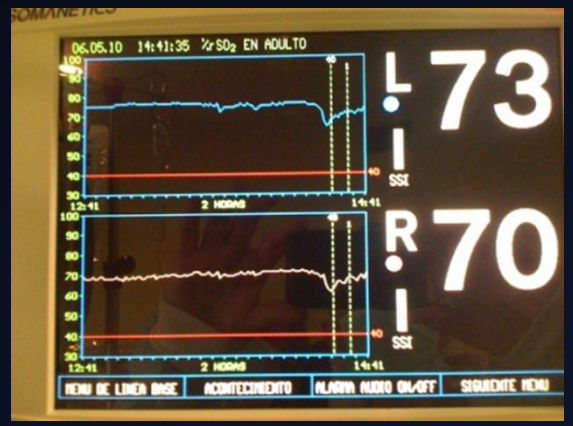
- Kam umístit ?

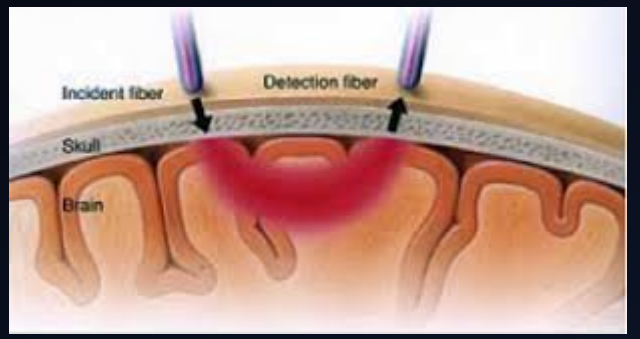

Penumbra:
Blood flow: 10-17 ml/100g/min
Electric silence
Spreading depression
Reversible damage in case of recirculation
Ischemic core:
Blood flow is permanently under <7.7-14 ml/100g/min
Irreversible membrane damage
Damaged brain tissue

Near Infrared Spectroscopy - NIRS

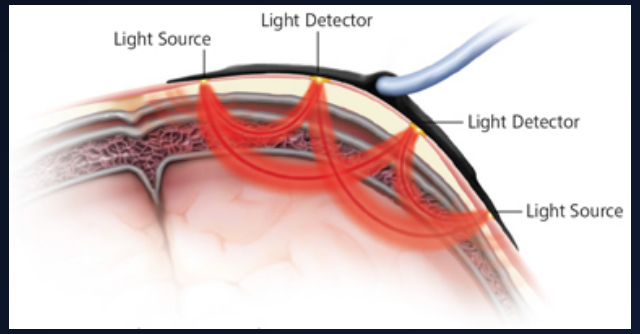
- $SctO_2$
- 60 – 75%
- 2/3-4/5 venózní krev

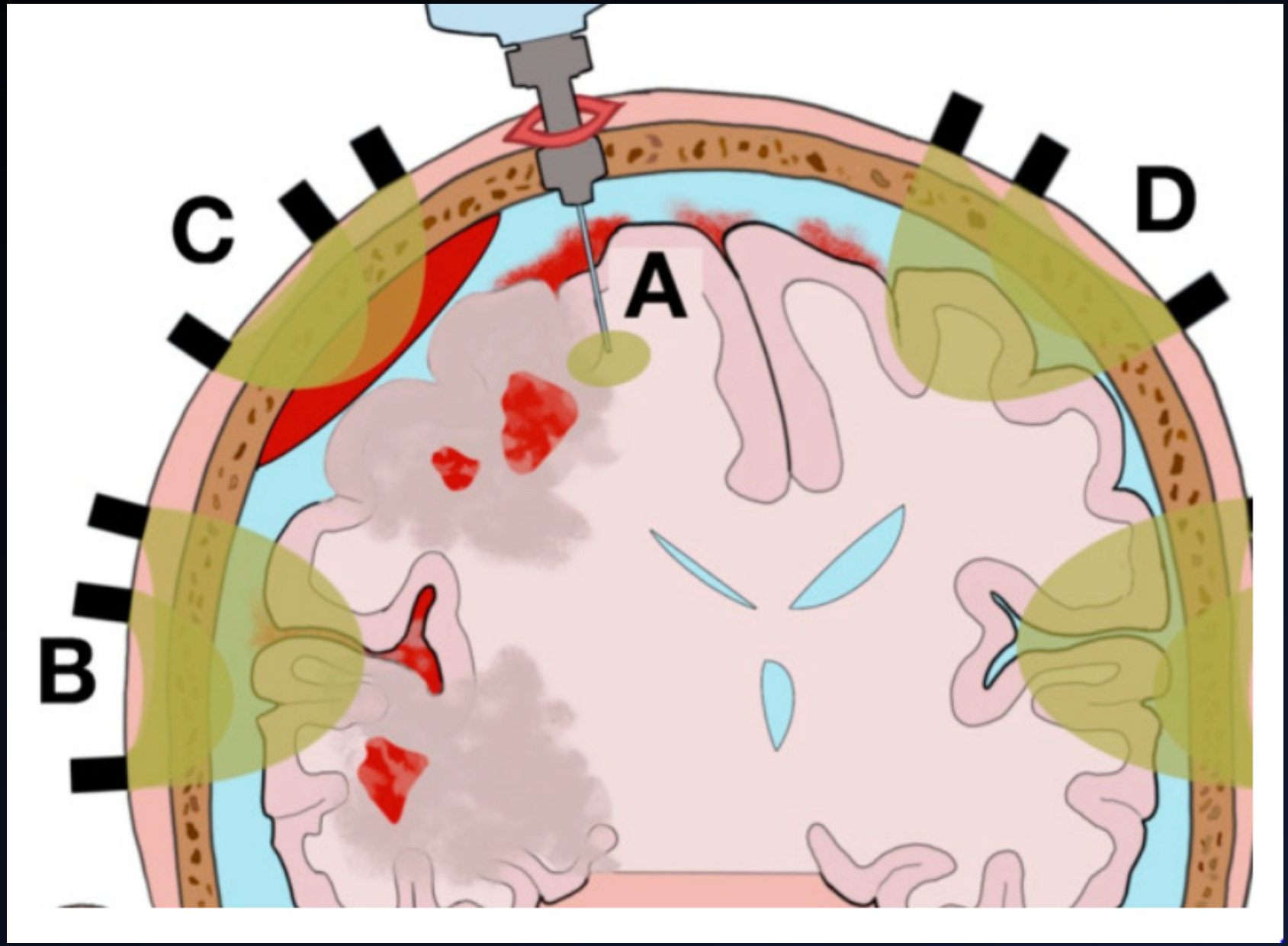
- 700-950nm










A
B
C
D

- TBI ??

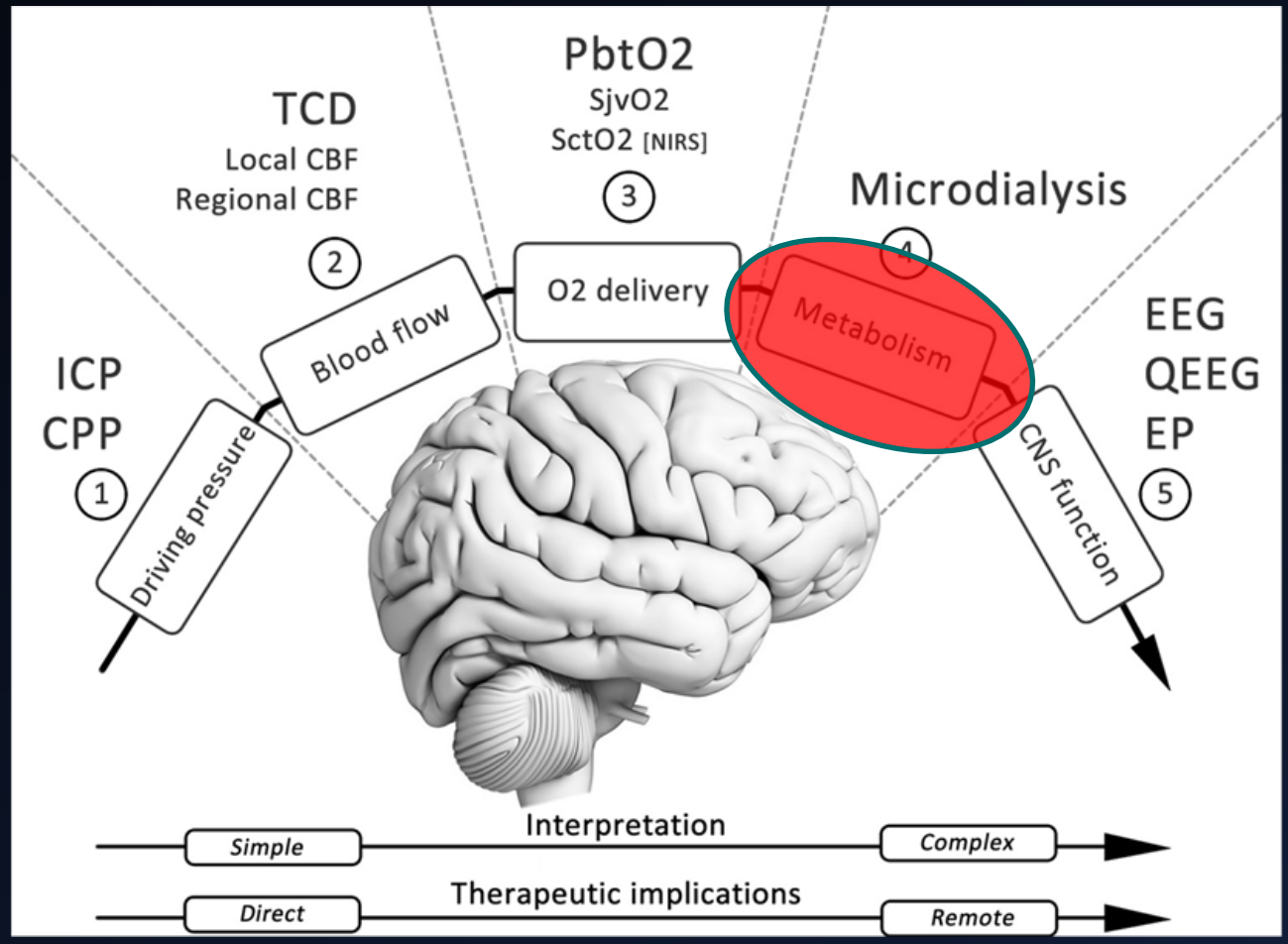
extracranial contamination

- EACI
- Kardiochirugie

III. Metabolismus

= mikrodialýza

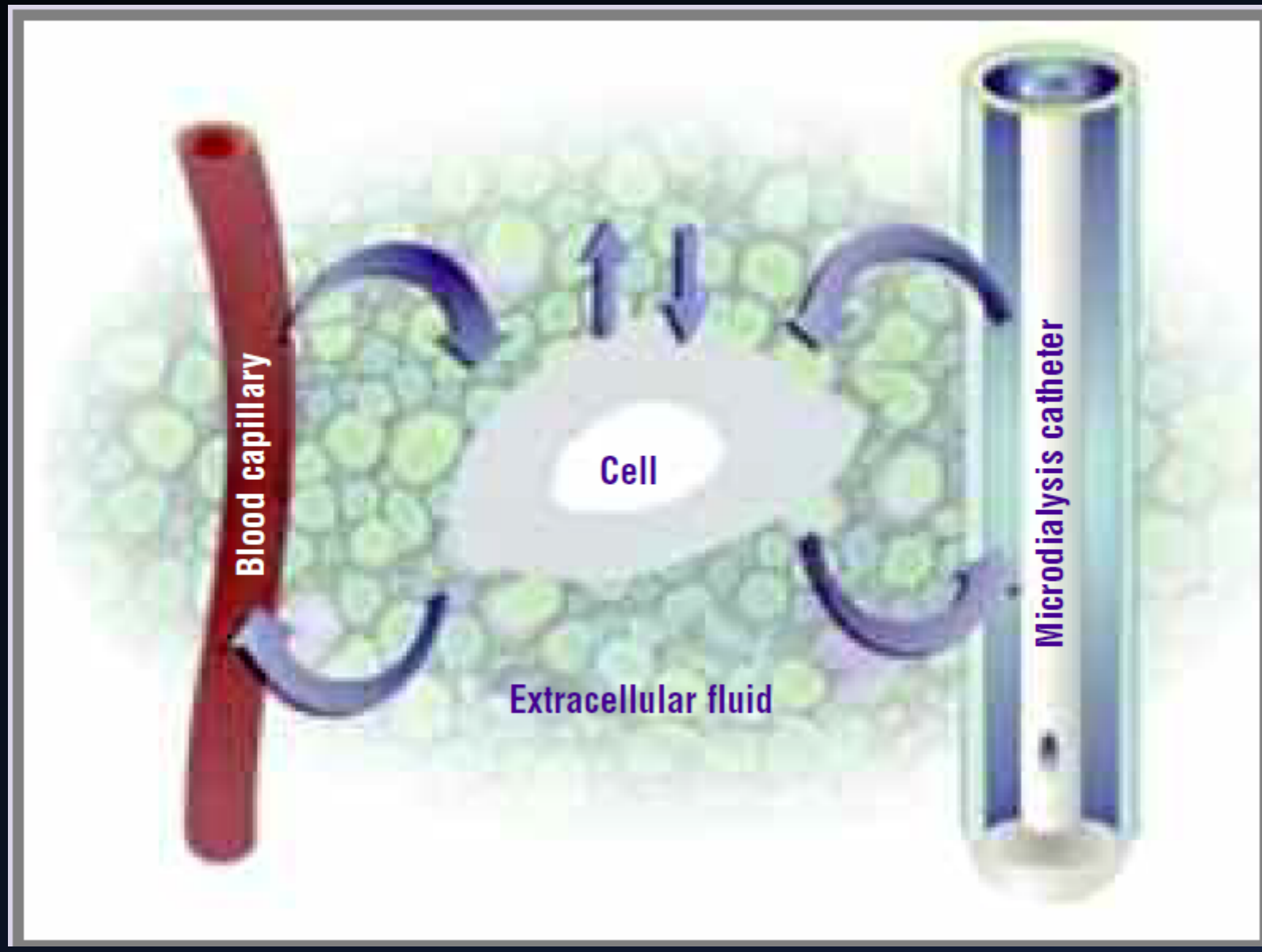
biomarkery



CMD

- 20kDa
- 0,3 µl/min

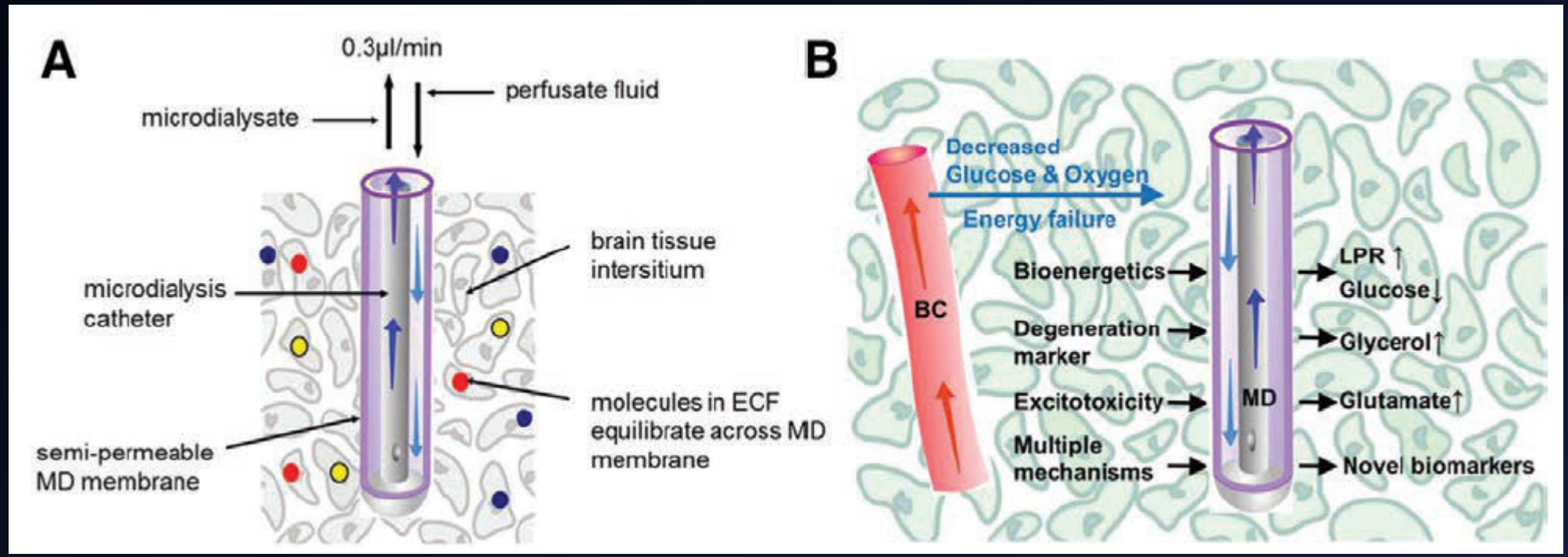
- 100kDa
- Makromolekuly
  - S100β
  - N-acetylaspartat
  - NO



Analyte	Brain	Subcutaneous
Glucose	1.5–2 mM	5 mM
Lactate	2 mM	
Pyruvate	120 μM	
Lactate/pyruvate	15–20	
Glycerol	50 μM	200 μM
Glutamate	10 μM	

Neurocrit Care (2015) 22:348–359

(ANESTHESIOLOGY 2018; 128:401-15)



Biomarkery

- S-100β
- Glial fibrillary acidic protein
- Neuron specific enolase
- Tau
- Amyloid β
- Neurofilament heavy chain
- Ubiquitin carboxy-terminal hydrolase
- Alpha II-spectrin

cells

MDPI

Systematic Review

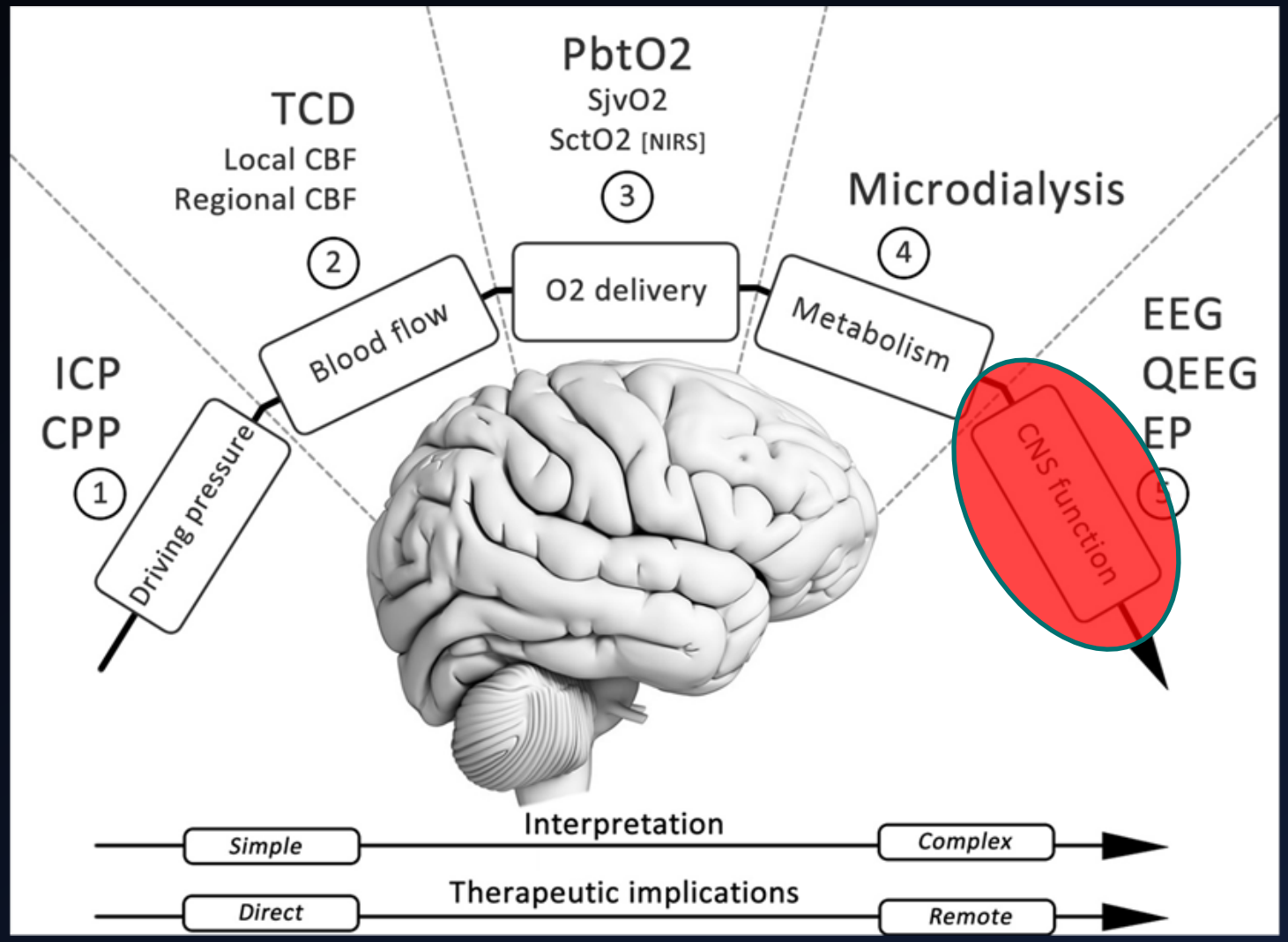
Raman Spectroscopy as a Neuromonitoring Tool in Traumatic Brain Injury: A Systematic Review and Clinical Perspectives

Author	Year	Type	Animal	Model Used	Raman Technique (Wavelength)	Overall Risk of Bias
Banbury et al.	2020	Article	Mouse	In vivo CCI mTBI/sTBI	Confocal RS (785 nm)	Moderate
Ercole et al.	2017	Abstract	Mouse	In vivo CCI sTBI	Confocal RS imaging (785 nm)	Moderate
Hu et al.	2016	Article	Rat	Stretch organotypic hippocampal slice cultures	Stimulated Raman scattering (720–990 nm pump beam, 1064 nm Stokes laser)	Moderate
Mowbray et al.	2021	Article	Rat	In vivo CCI sTBI	Confocal RS (785 nm)	Moderate
Surmacki et al.	2016	Article	Mouse	In vivo CCI	Confocal RS (785 nm)	Moderate
Tay et al.	2011	Article	Mouse	In vivo CCI	Confocal RS (785 nm)	Moderate
Kawon et al.	2021	Article	Rat	In vivo drill focal injury	Confocal RS (532 nm)—Additionally, FTIR-only Raman findings reported in this article	Moderate

IV. Funkce

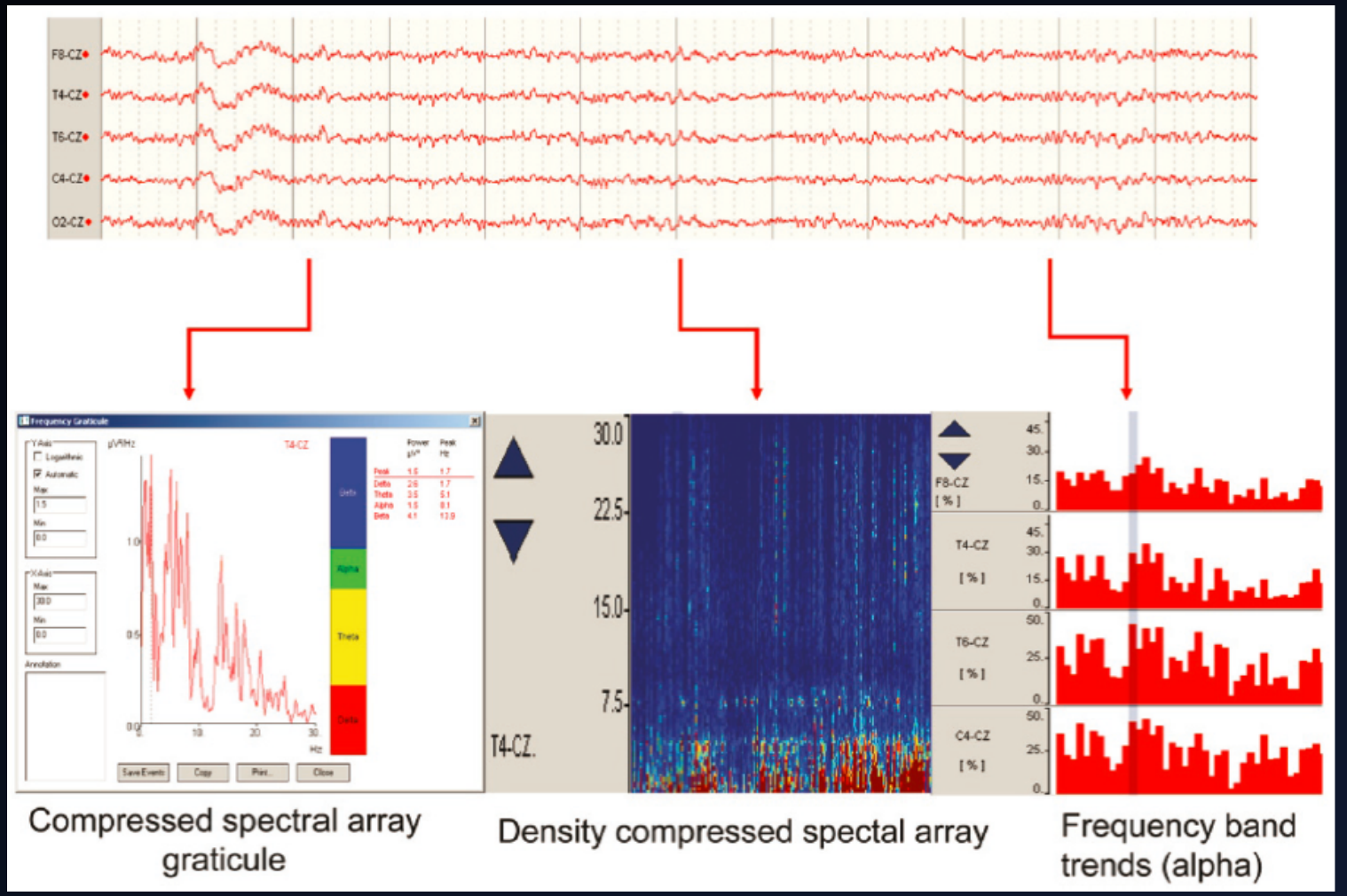
- elektrofyziologie





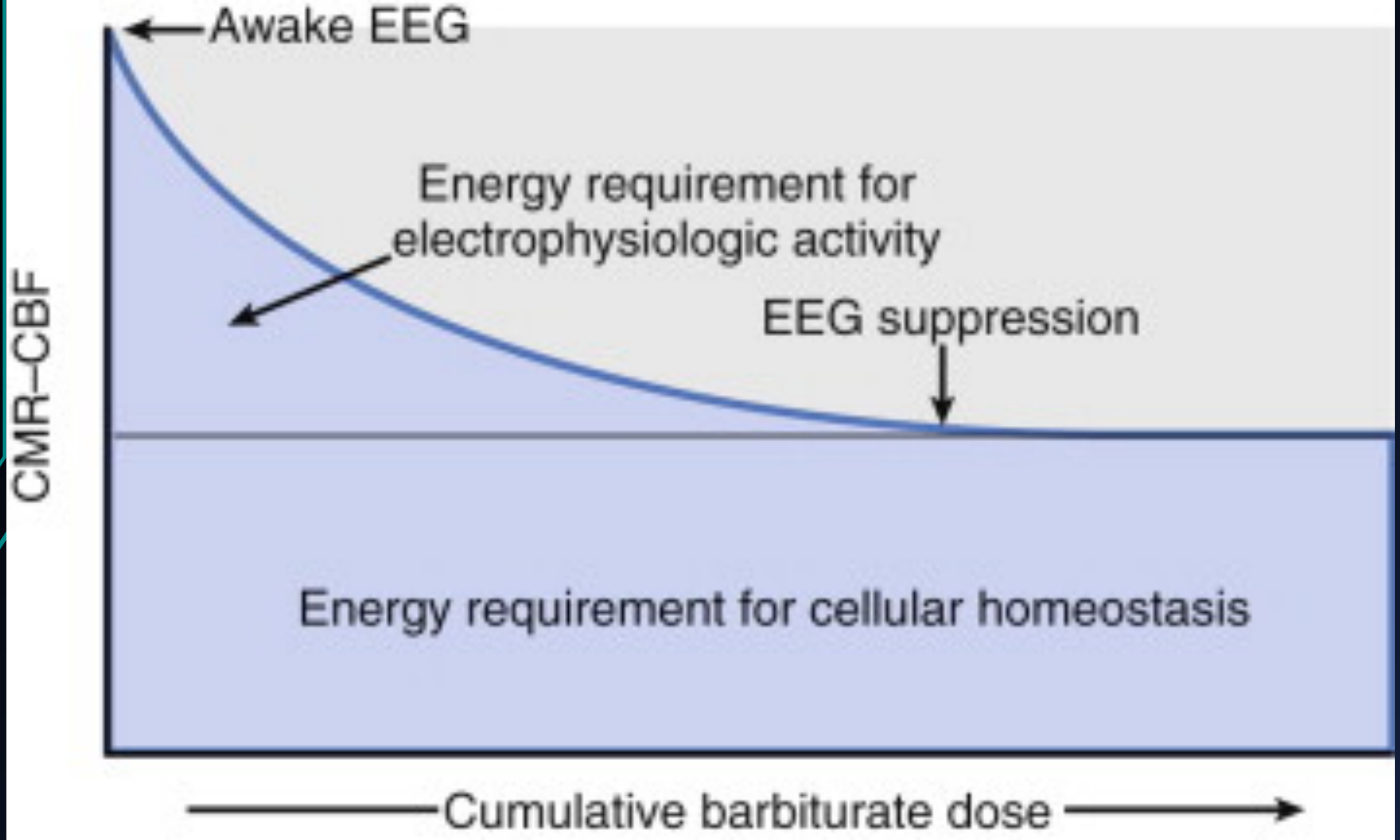
EEG

- 20-40% TBI epilepsie
  - Nekonvulzivní
- qEEG

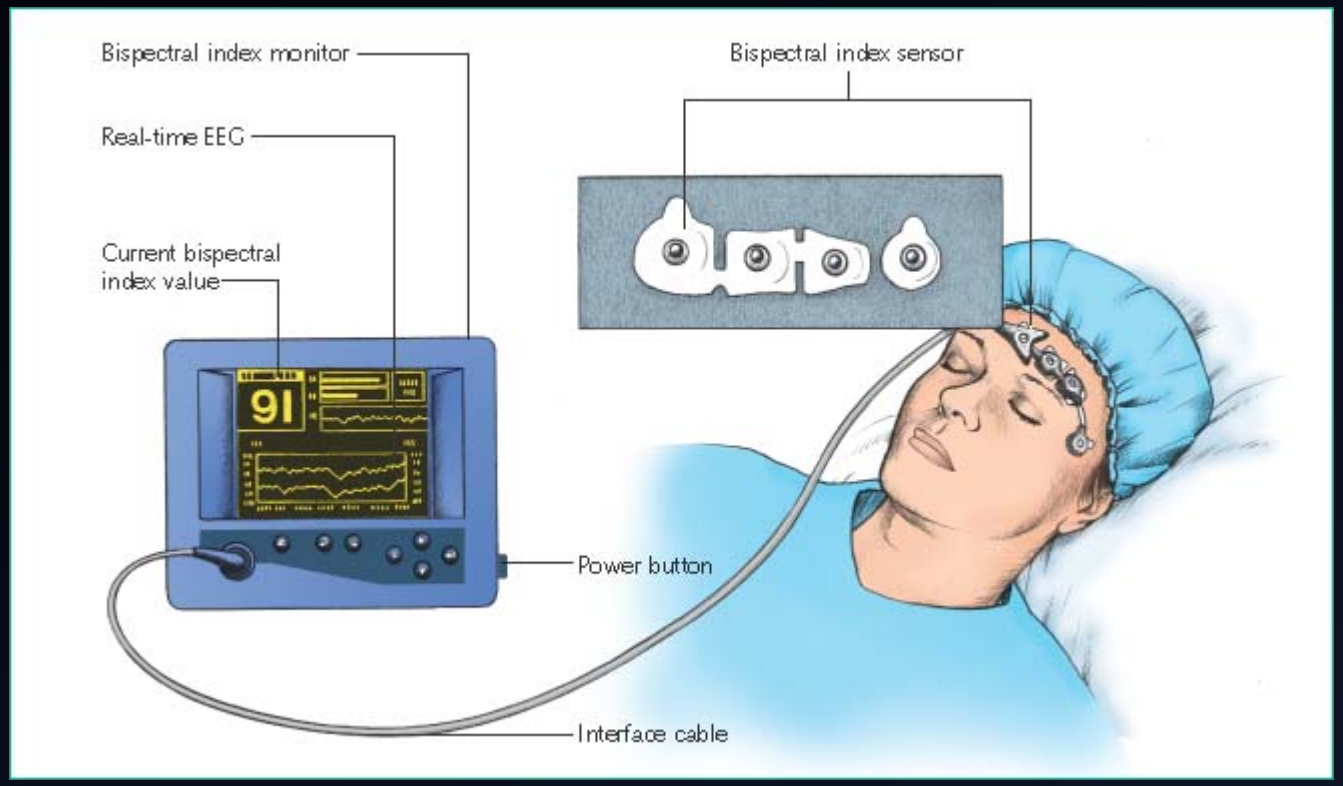


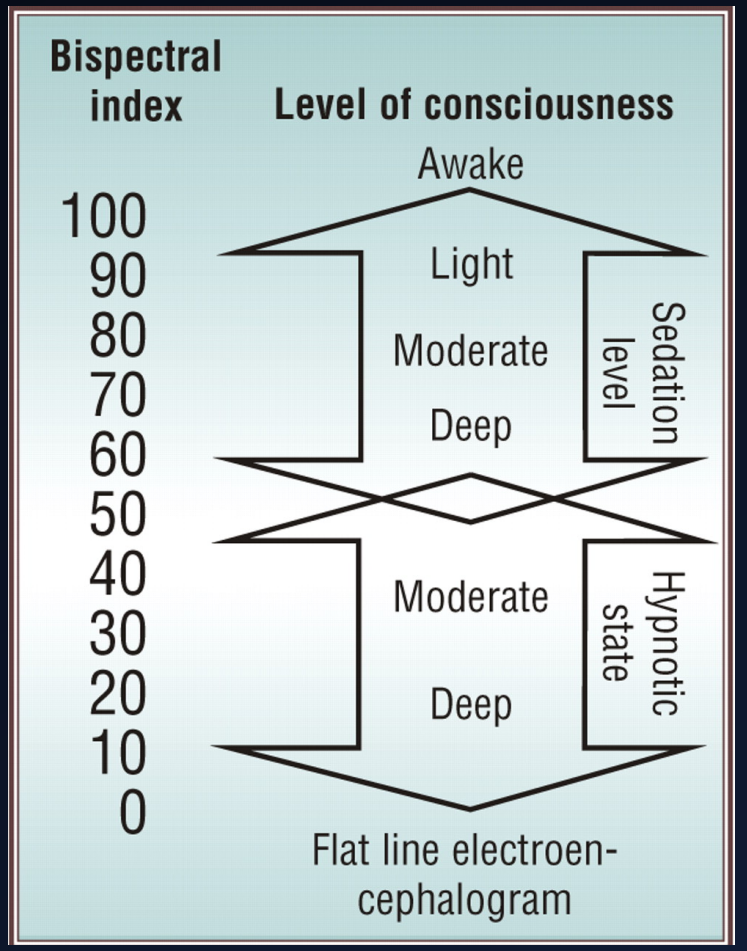
- Kortikální snímání
  - Spreading depolarization – 50% TBI

Stocchetti *et al. Critical Care* 2013, **17**:201
http://ccforum.com/content/17/1/201


Awake EEG
Energy requirement for
electrophysiologic activity
EEG suppression
Energy requirement for cellular homeostasis
CMR–CBF
Cumulative barbiturate dose

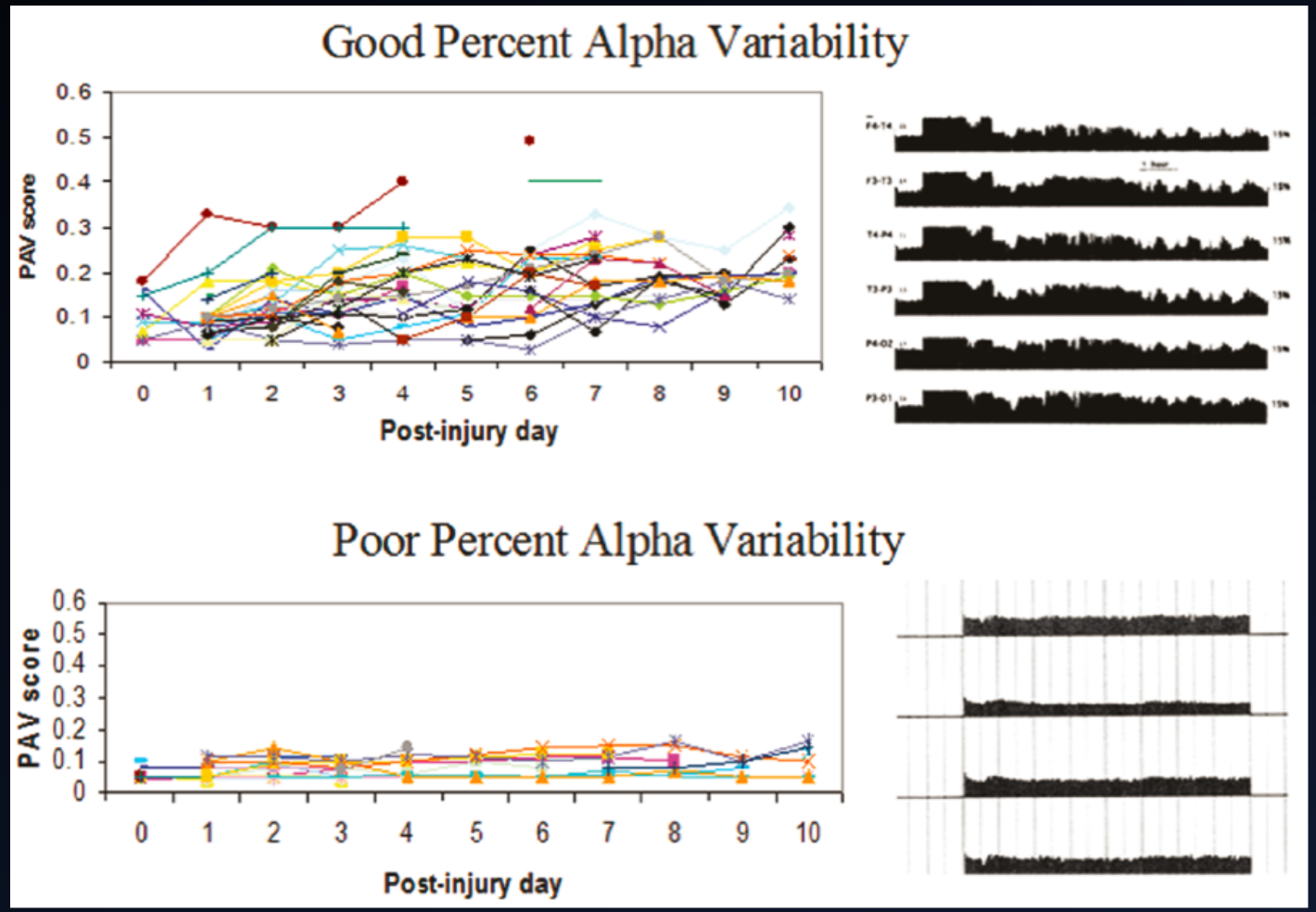
BIS


Bispectral index monitor
Real-time EEG
Current bispectral index value
Bispectral index sensor
91
Power button
Interface cable

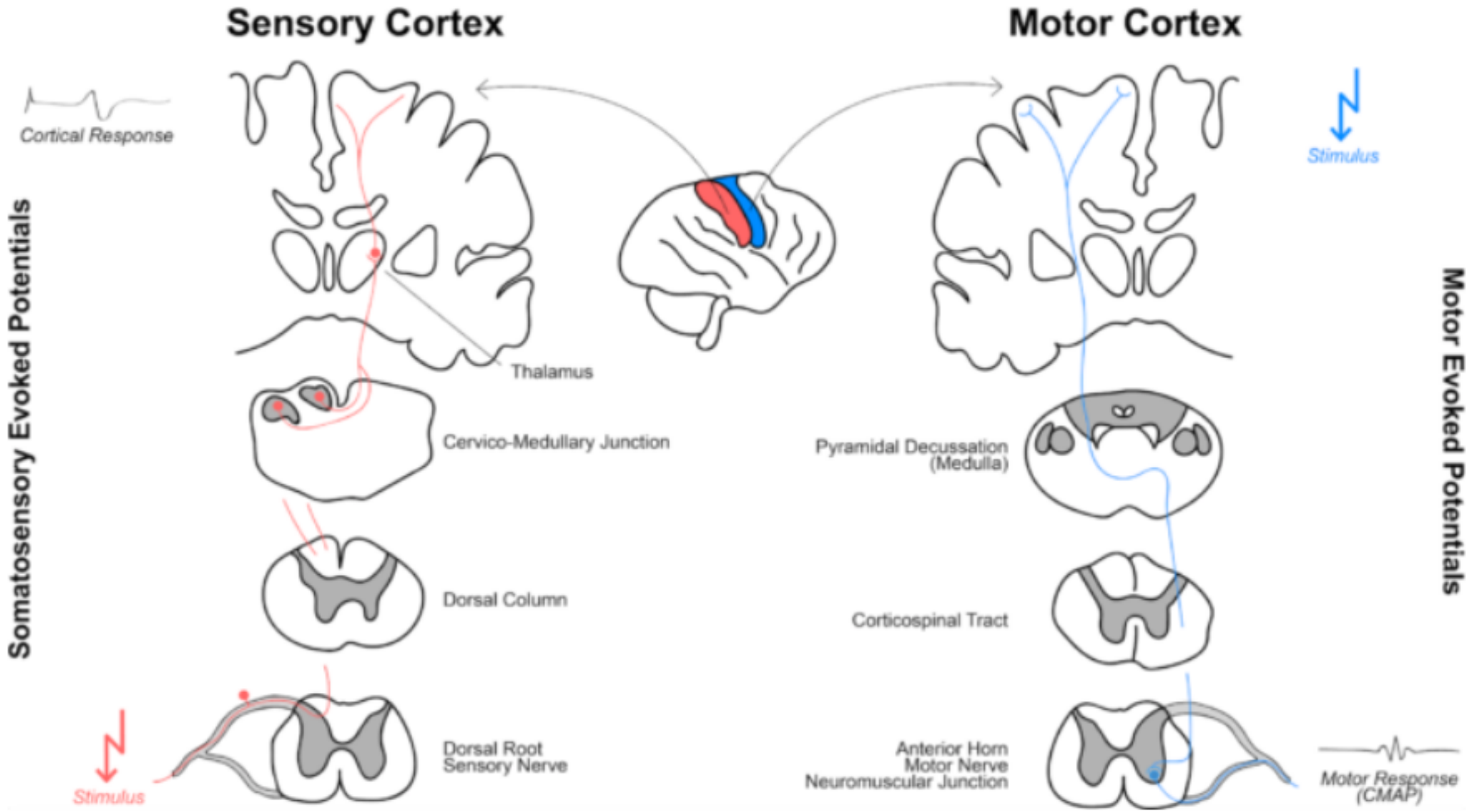

Bispectral index
Level of consciousness
Awake
100
90
80
70
60
50
40
30
20
10
0
Light
Moderate
Deep
Sedation level
Moderate
Deep
Hypnotic state
Flat line electroen-cephalogram

- Diagnóza
- Léčba
- Prognóza





Stocchetti *et al. Critical Care* 2013, 17:201
http://ccforum.com/content/17/1/201

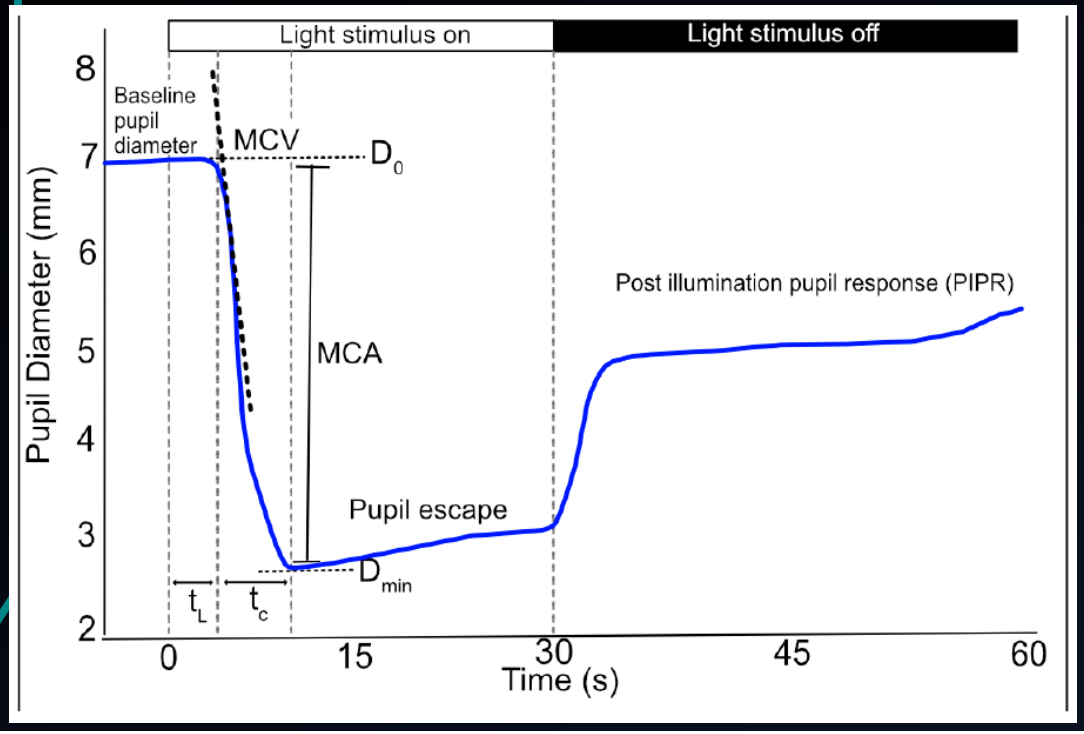

Sensory Cortex
Motor Cortex
Cortical Response
Stimulus
Somatosensory Evoked Potentials
Motor Evoked Potentials
Thalamus
Cervico-Medullary Junction
Dorsal Column
Dorsal Root
Sensory Nerve
Stimulus
Pyramidal Decussation
(Medulla)
Corticospinal Tract
Anterior Horn
Motor Nerve
Neuromuscular Junction
Motor Response
(CMAP)



Agent	SSEP		MEP		BAEP	
	Latency	Amplitude	Latency	Amplitude	Latency	Amplitude
Opioids	—	↓	—	↓	—	—
Ketamine	↑	↑	—	↑	—	↑
Etomidate	↑	↑	—	↑	↑	↑
Barbiturates-low dose	—	—	↑	↓↓	—	—
Barbiturates-high dose	↑	↓	↑	↓↓	↑	↓
Benzodiazepines-low dose	—	—	—	—	—	—
Dexmedetomidine	—	↓	—	↓	—	—
Propofol	↑	↓	↑	↓	↑	—
NMBA	—	—	↑	↓↓	—	—

	SSEP		MEP		BAEP	
	Latency	Amplitude	Latency	Amplitude	Latency	Amplitude
Halogenated agents	↑	↓	↑	↓	↑	—
N_2O	↑	↓	↑	↓	—	↓

Pupilometrie



KPR
bolest

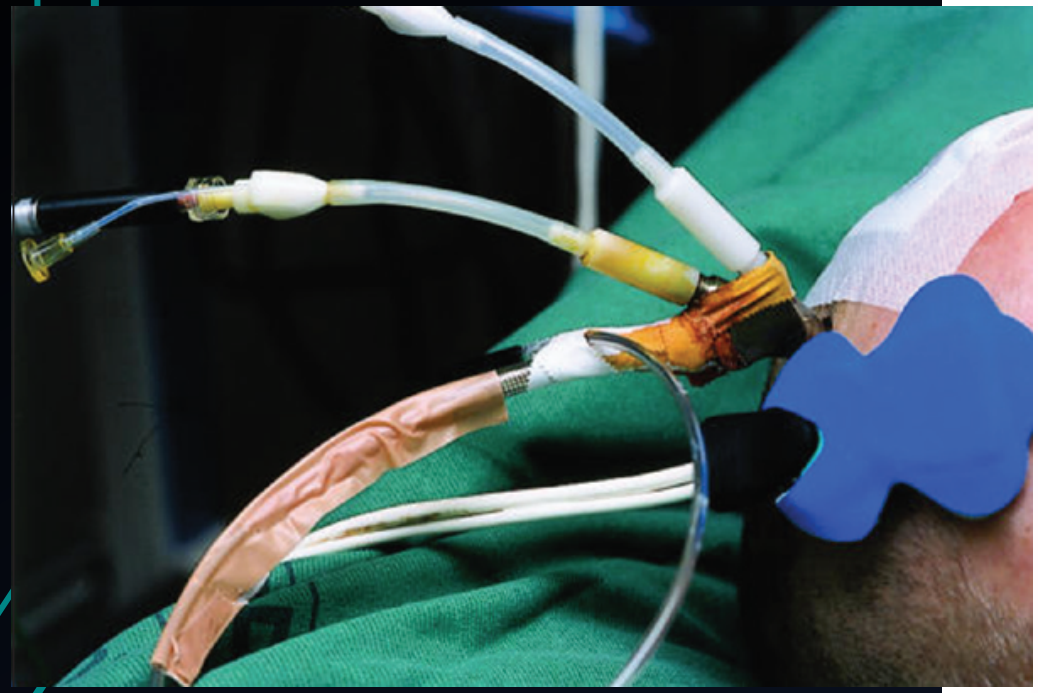


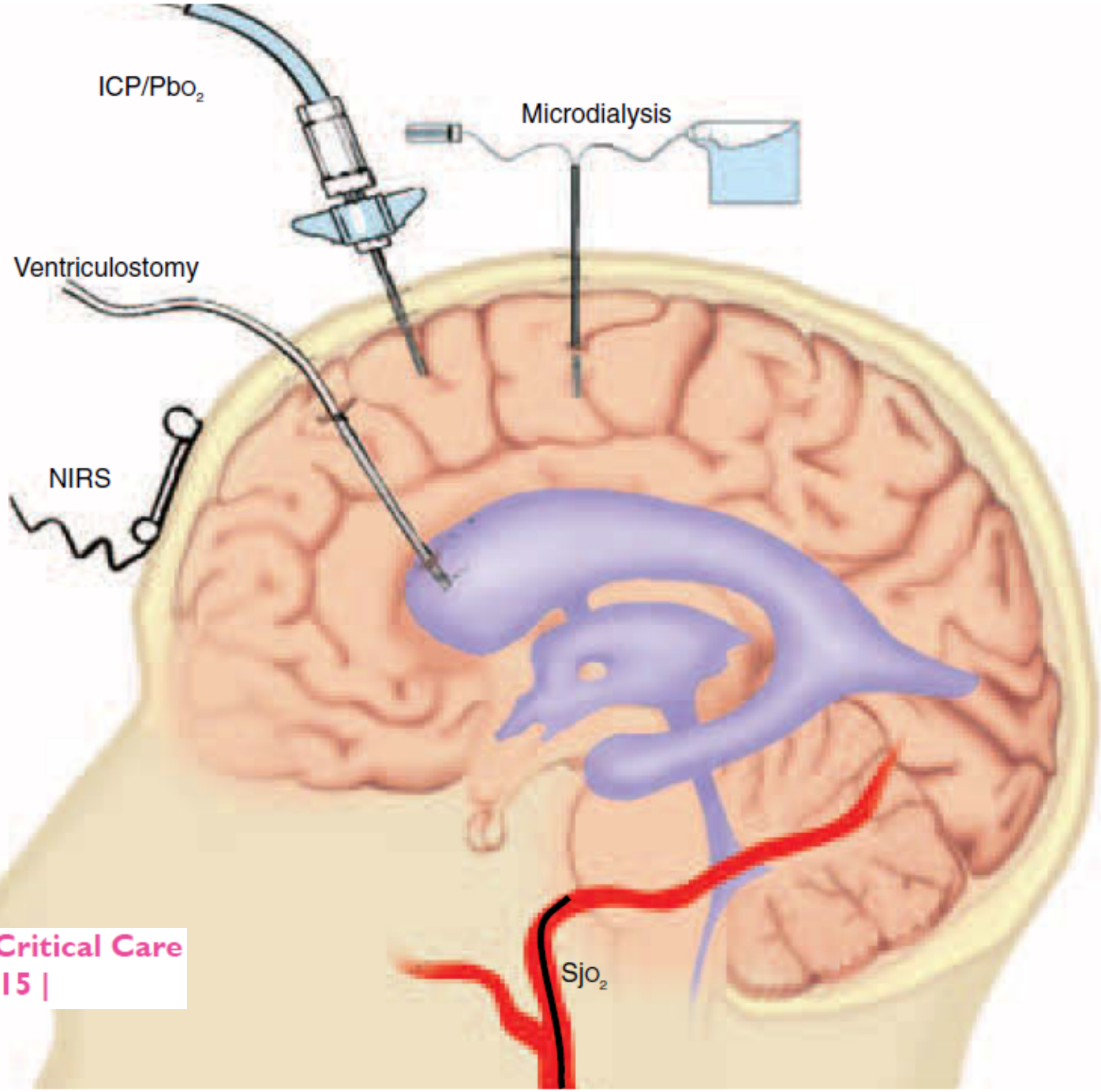
Review

Eyeing up the Future of the Pupillary Light Reflex in Neurodiagnostics

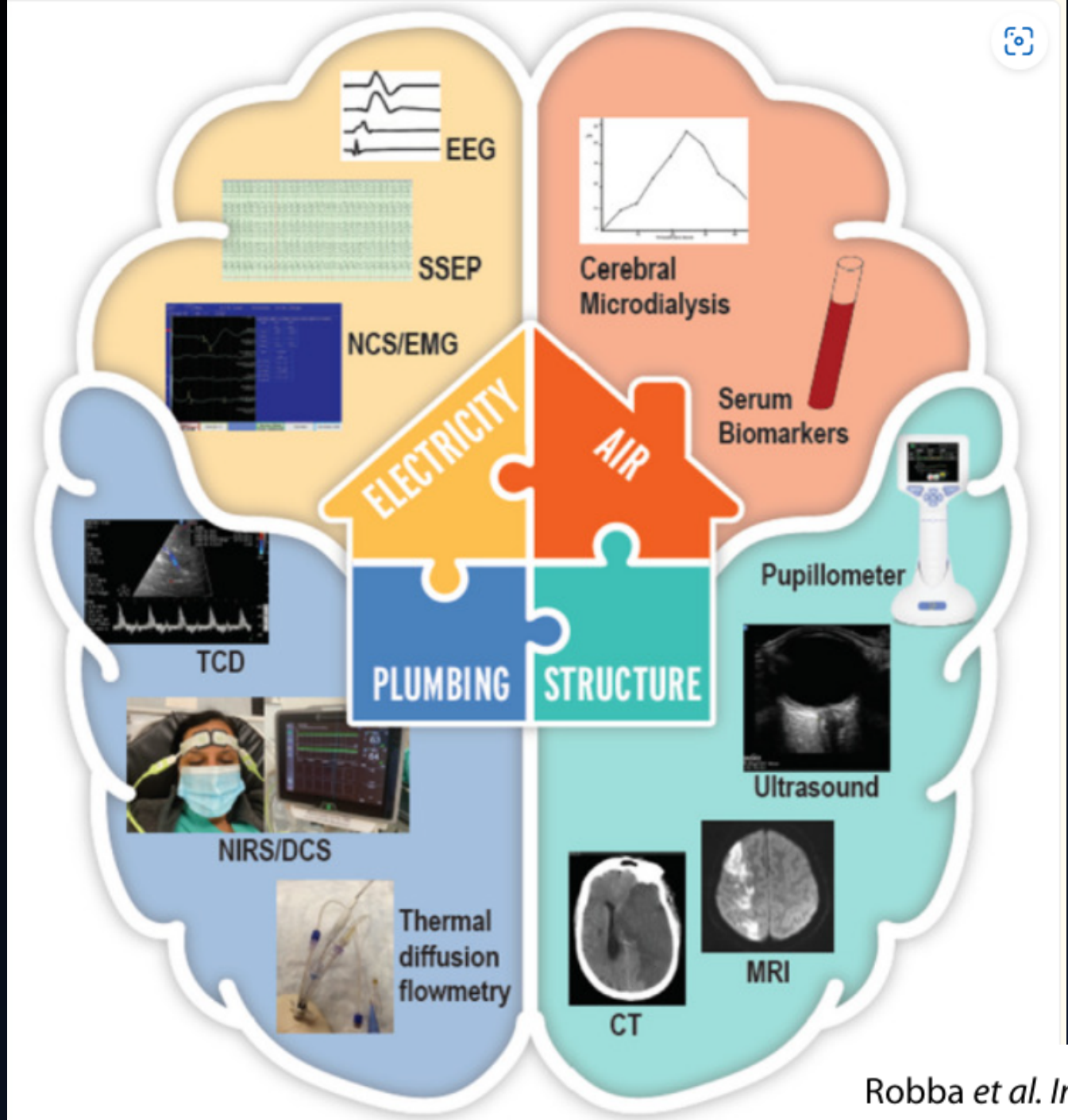
Diagnostics **2018**, *8*, 19; doi:10.3390/diagnostics8010019

The pupillary light reflex serves as a valuable indicator of autonomic nervous system function. Moreover, measurement of the reflex using dynamic pupillometry provides a quantitative, non-invasive tool, which may aid the diagnosis and clinical management of a wide range of clinical conditions, varying from neurodegenerative disease to exposure to toxic chemicals.

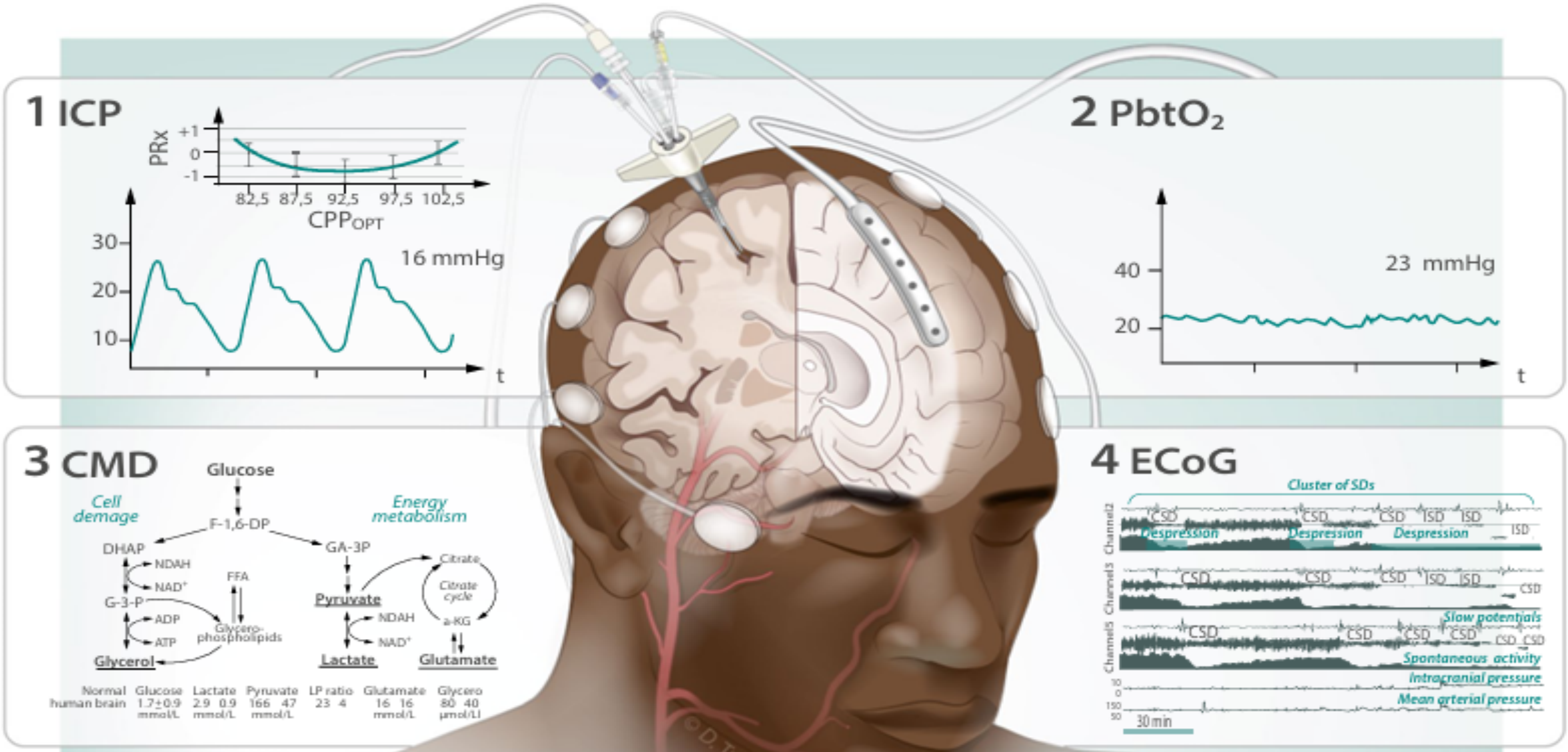




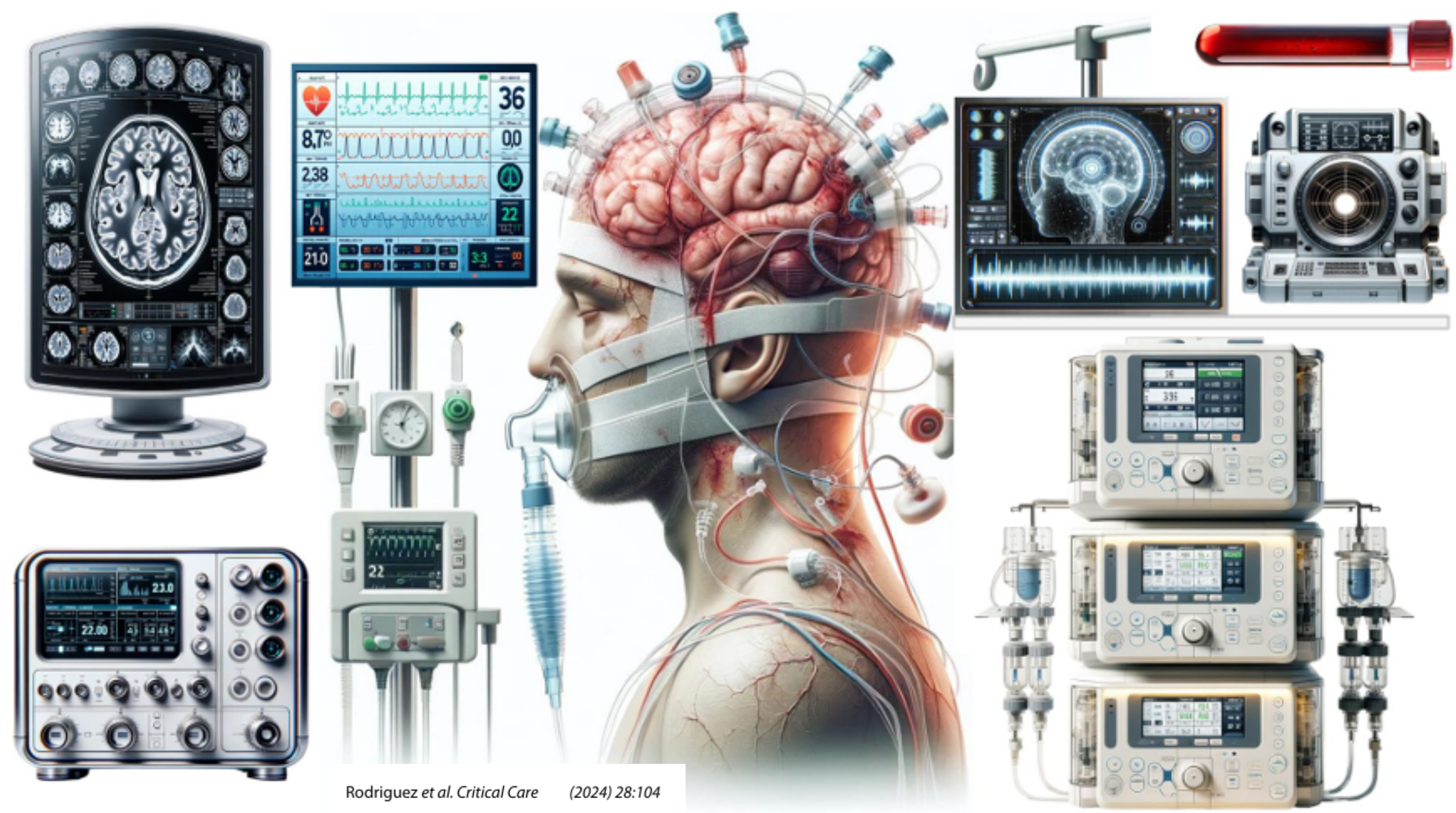
Journal of Neuroanaesthesiology and Critical Care
| Vol. 2 • Issue 2 • May-Aug 2015 |



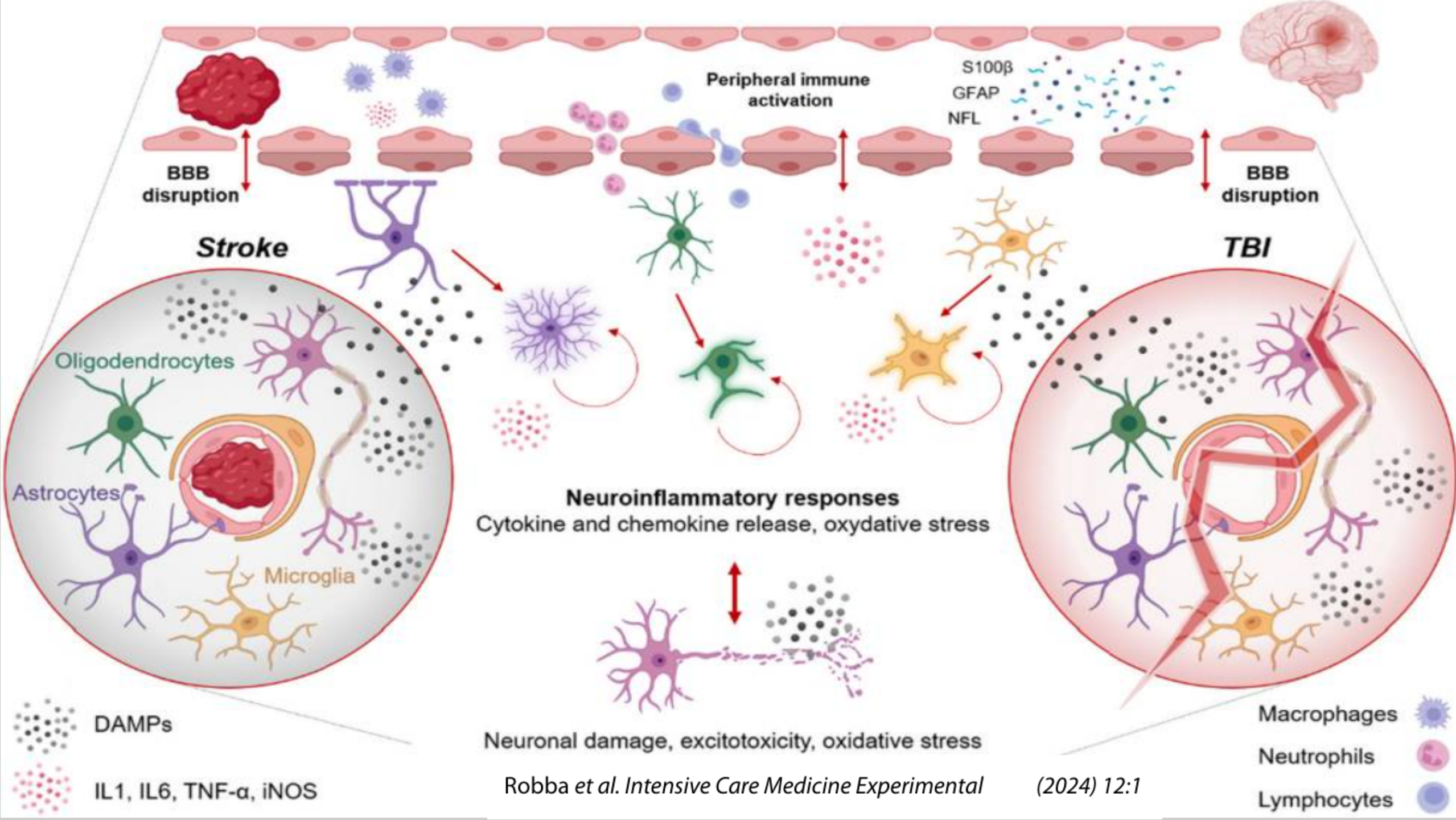
Robba *et al. Intensive Care Medicine Experimental* (2024) 12:1



Neurotherapeutics (2023) 20:1457–1471
https://doi.org/10.1007/s13311-023-01411-2

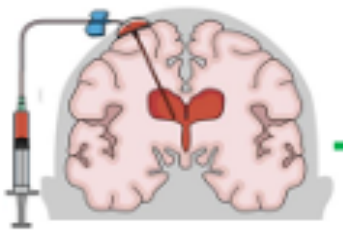


Rodriguez *et al. Critical Care* (2024) 28:104



Robba *et al. Intensive Care Medicine Experimental* (2024) 12:1

	Main Effects in TBI	Highlights
IL1β	Detrimental	Raised CSF IL1β correlates with both raised ICP and poorer outcome. The balance between members of the IL1 cytokine family, in particular between IL1β and its endogenous inhibitor IL1ra, is an important determinant of the degree of inflammatory response, rather than the absolute concentration of IL1β. In TBI patients, high microdialysate IL1ra/IL1b ratio is associated to favourable outcomes [54–56].
TNFα	Detrimental in acute phase and beneficial during the healing process	Upregulated in the injured brain early after trauma, reaching a peak within a few hours following the initial injury. This cytokine triggers the apoptotic cascade but also, pathways resulting in activation of pro-survival genes [57–59].
IL6	Beneficial	A trophic factor that is upregulated in the CNS after injury and promotes neuronal survival and brain repair through astroglia and vascular remodelling. Following TBI, its concentration rises dramatically [60,61].
Complement	Detrimental	The complement system significantly triggers inflammation in TBI, increasing BBB permeability and inducing cytokines, chemokines, and adhesion molecules. Key products like C3a and C5a enhance vascular permeability and inflammation. The cascade forms the membrane attack complex (MAC), affecting both non-nucleated and nucleated cells. C5a, a major pro-inflammatory component, amplifies cytokine production and leukocyte adhesion, leading to more inflammation. This system also contributes to apoptosis and cell death in TBI [62–64].
Angiopoietins	Beneficial (Ang1) and detrimental (Ang2)	They are family of growth factors that are important in regulating angiogenesis and vascular permeability, and also have been implicated in BBB disruption. TBIs models show acute decrease in Angiopoetin-1 expression and concomitant increase in Angiopoetin-2 which is associated with endothelial apoptosis and BBB permeability [65–69].



ICP

<15 mmHg

NO DC → No Therapy / Reduce TIL

DC

15-25 mmHg

Brain Compliance

Reduced Compliance → ICP Therapy / Escalate TIL

Normal Compliance → No Therapy

Tissue Oxygenation

CMD Available

Tissue Hypoxia / Normal LPR → No Therapy

No Tissue Hypoxia / High LPR → Metabolic Crisis

Tissue Hypoxia / High LPR → Treat "Hypoxia"

No Tissue Hypoxia / Normal LPR → No Therapy

CMD Not Available

Tissue Hypoxia → Therapy

No Tissue Hypoxia → No Therapy

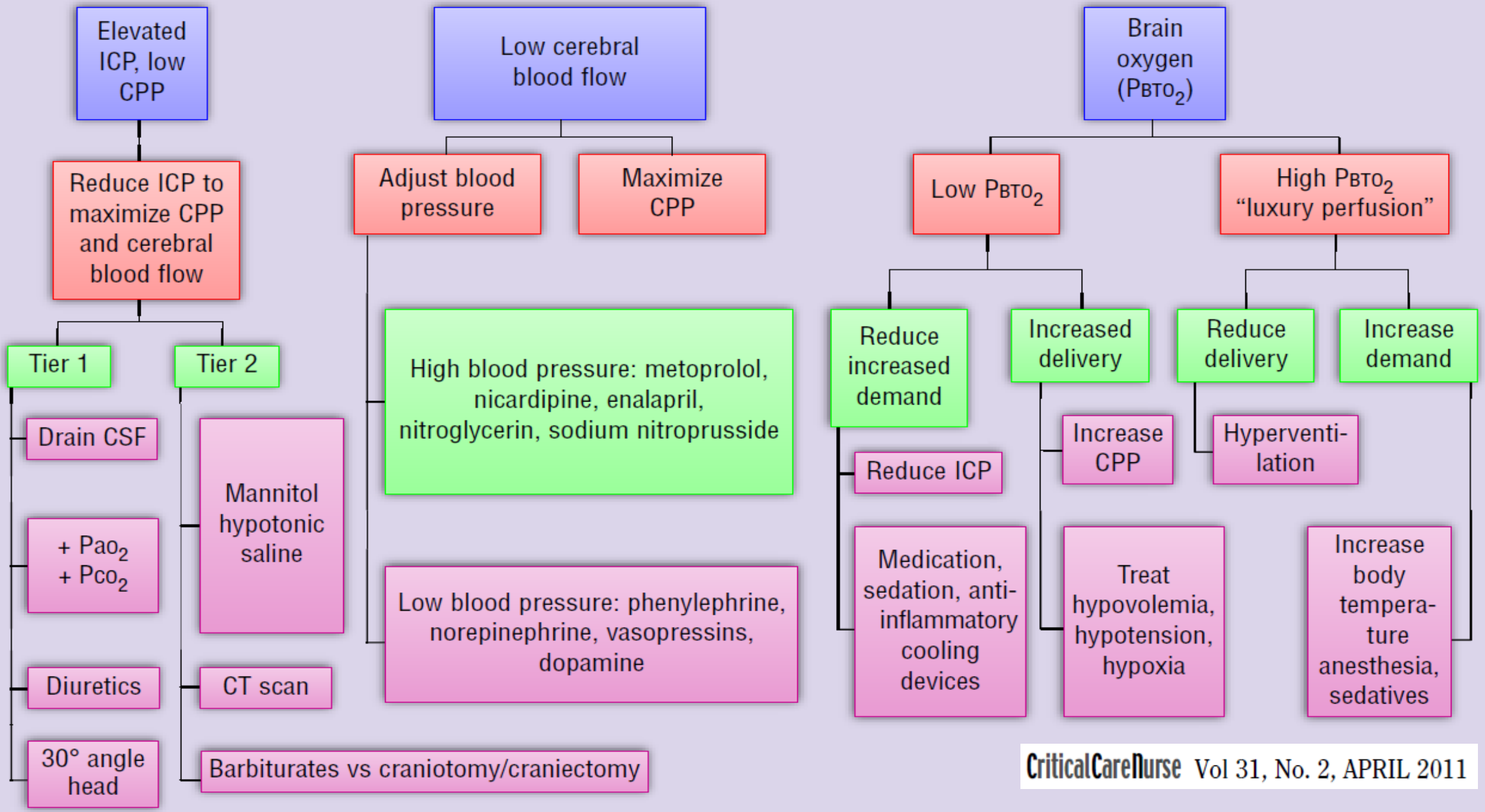
>25 mmHg

SSCIs → Treat Systemic Variables

ICP < 25 mmHg

ICP > 25 mmHg → ICP Therapy / Escalate TIL

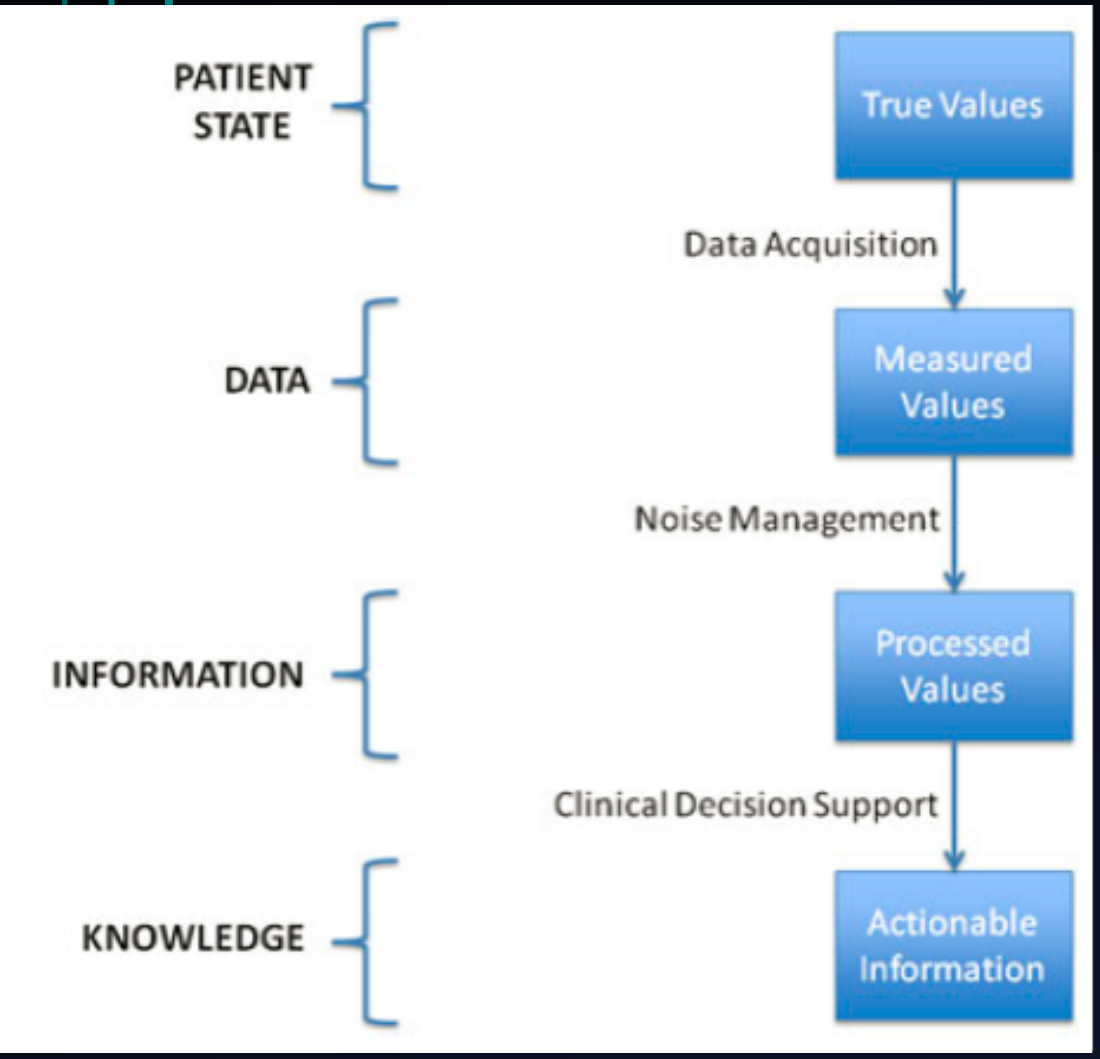
NO SSCIs → ICP Therapy / Escalate TIL

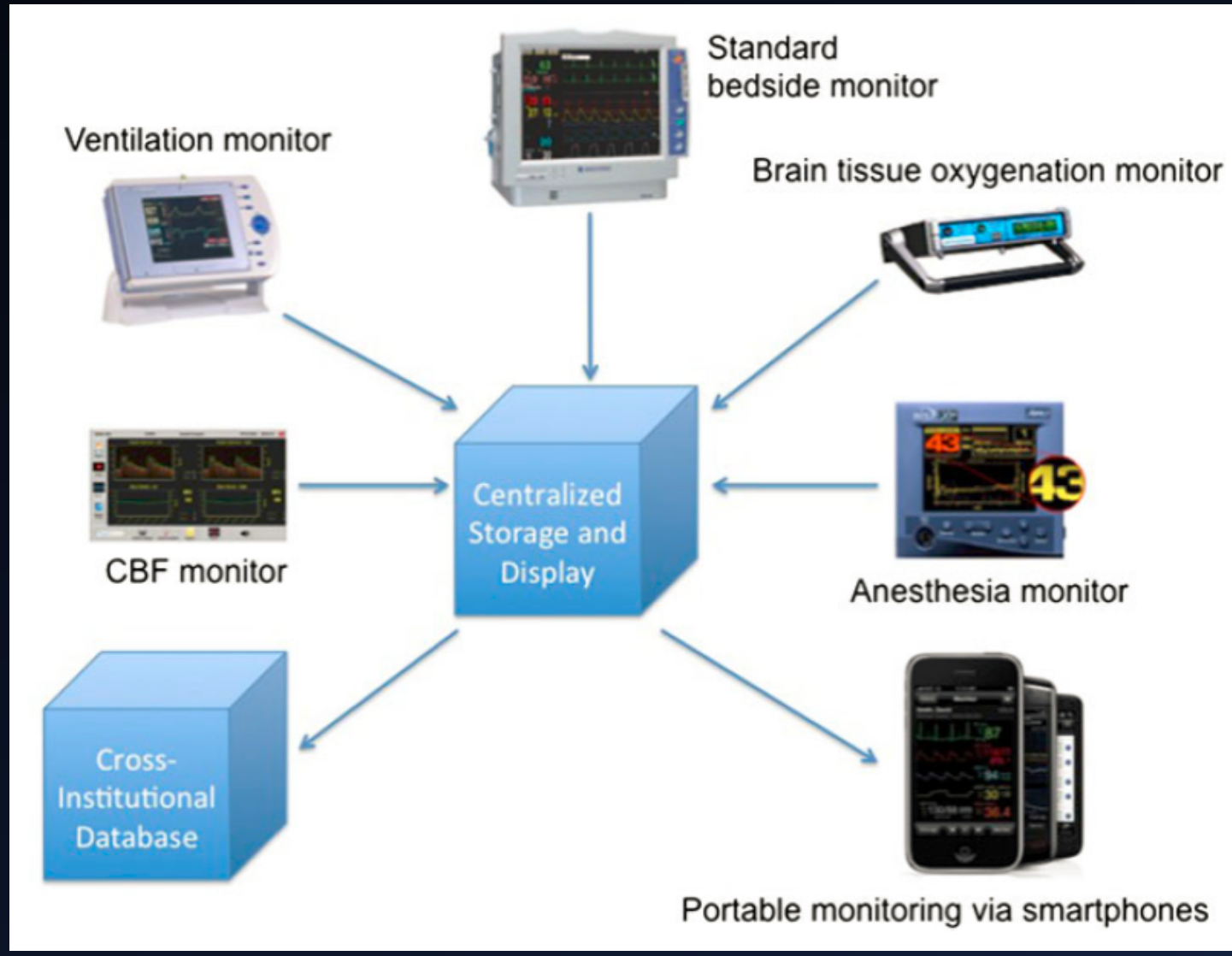


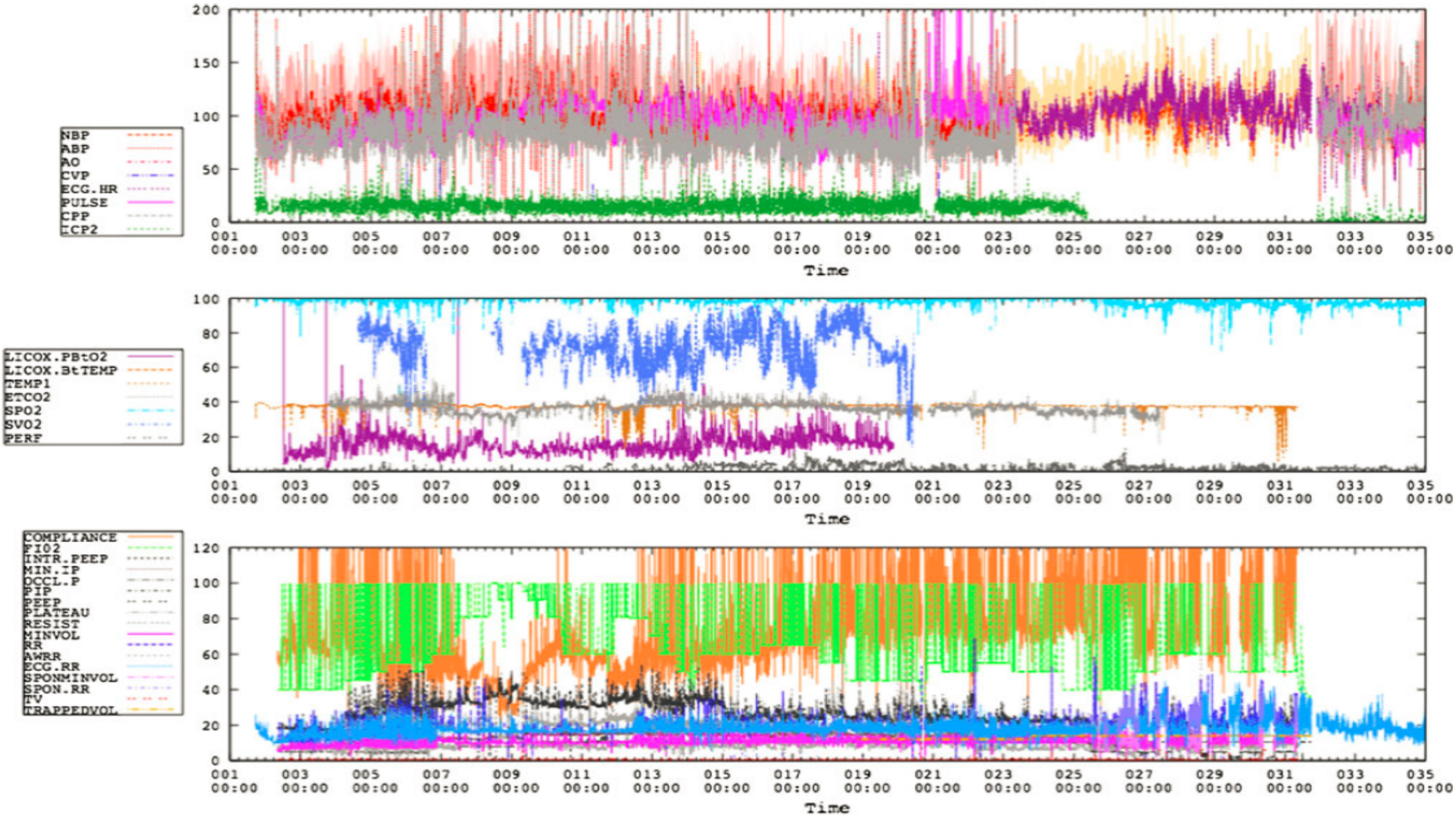
CriticalCareNurse Vol 31, No. 2, APRIL 2011

Informatics for Neurocritical Care: Challenges and Opportunities

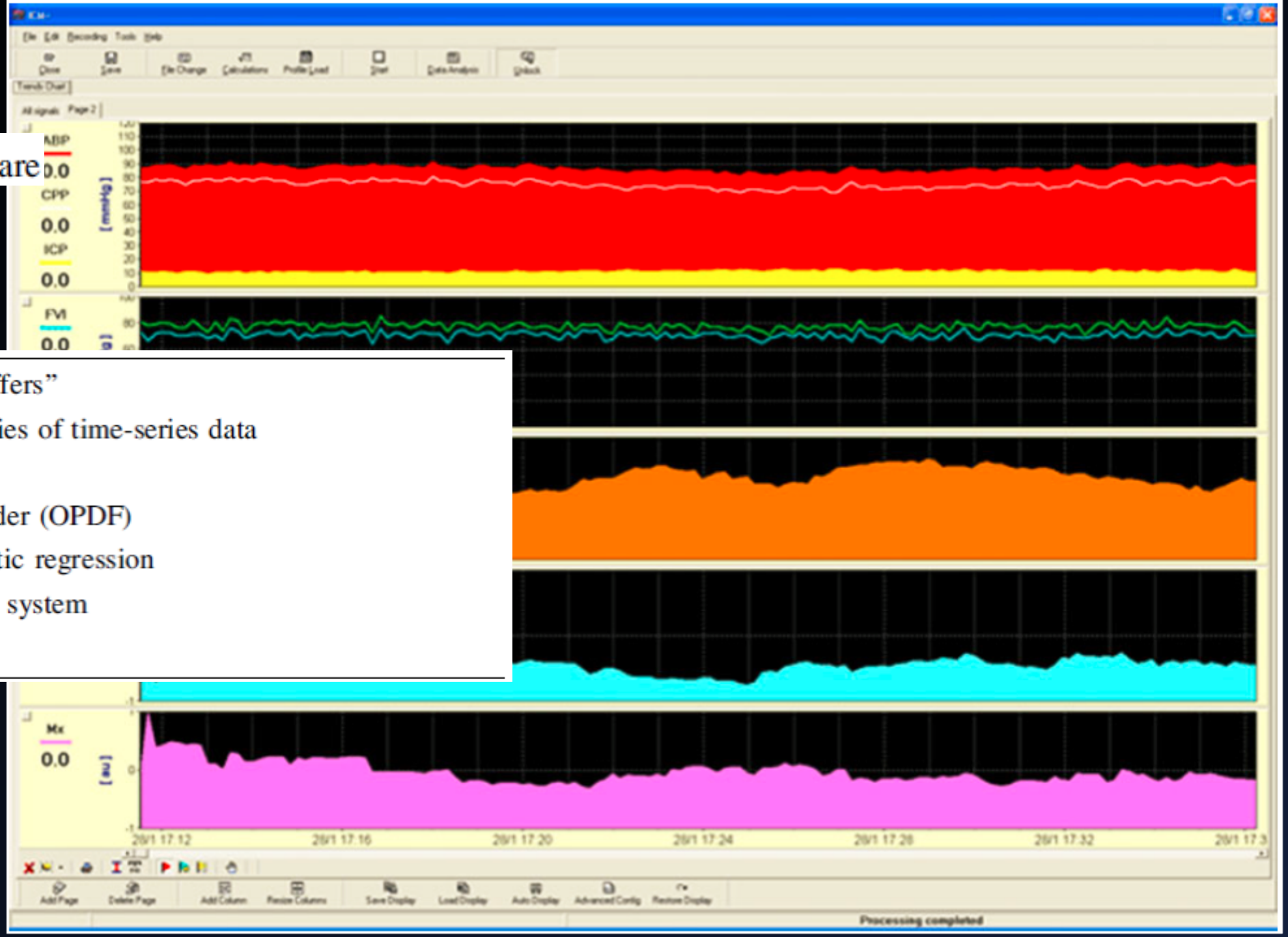
Neurocrit Care (2014) 20:132–141






NBP
ABP
AO
CVP
ECG.HR
PULSE
CPP
ECP2
200
150
100
50
0
001 00:00
003 00:00
005 00:00
007 00:00
009 00:00
011 00:00
013 00:00
015 00:00
017 00:00
019 00:00
021 00:00
023 00:00
025 00:00
027 00:00
029 00:00
031 00:00
033 00:00
035 00:00
Time
LICOX.PBtO2
LICOX.BtTEMP
TEMP1
ETCO2
SPO2
SVO2
PERF
100
80
60
40
20
0
001 00:00
003 00:00
005 00:00
007 00:00
009 00:00
011 00:00
013 00:00
015 00:00
017 00:00
019 00:00
021 00:00
023 00:00
025 00:00
027 00:00
029 00:00
031 00:00
033 00:00
035 00:00
Time
COMPLIANCE
FI02
INTR.PEEP
MIN.IP
OCCL.P
PIP
PEEP
PLATEAU
RESIST
MINVOL
RR
AWRR
ECG.RR
SPONMINVOL
SPON.RR
TV
TRAPPEDVOL
120
100
80
60
40
20
0
001 00:00
003 00:00
005 00:00
007 00:00
009 00:00
011 00:00
013 00:00
015 00:00
017 00:00
019 00:00
021 00:00
023 00:00
025 00:00
027 00:00
029 00:00
031 00:00
033 00:00
035 00:00
Time

ICM+ software



Rule-based “software sniffers”

Natural language summaries of time-series data

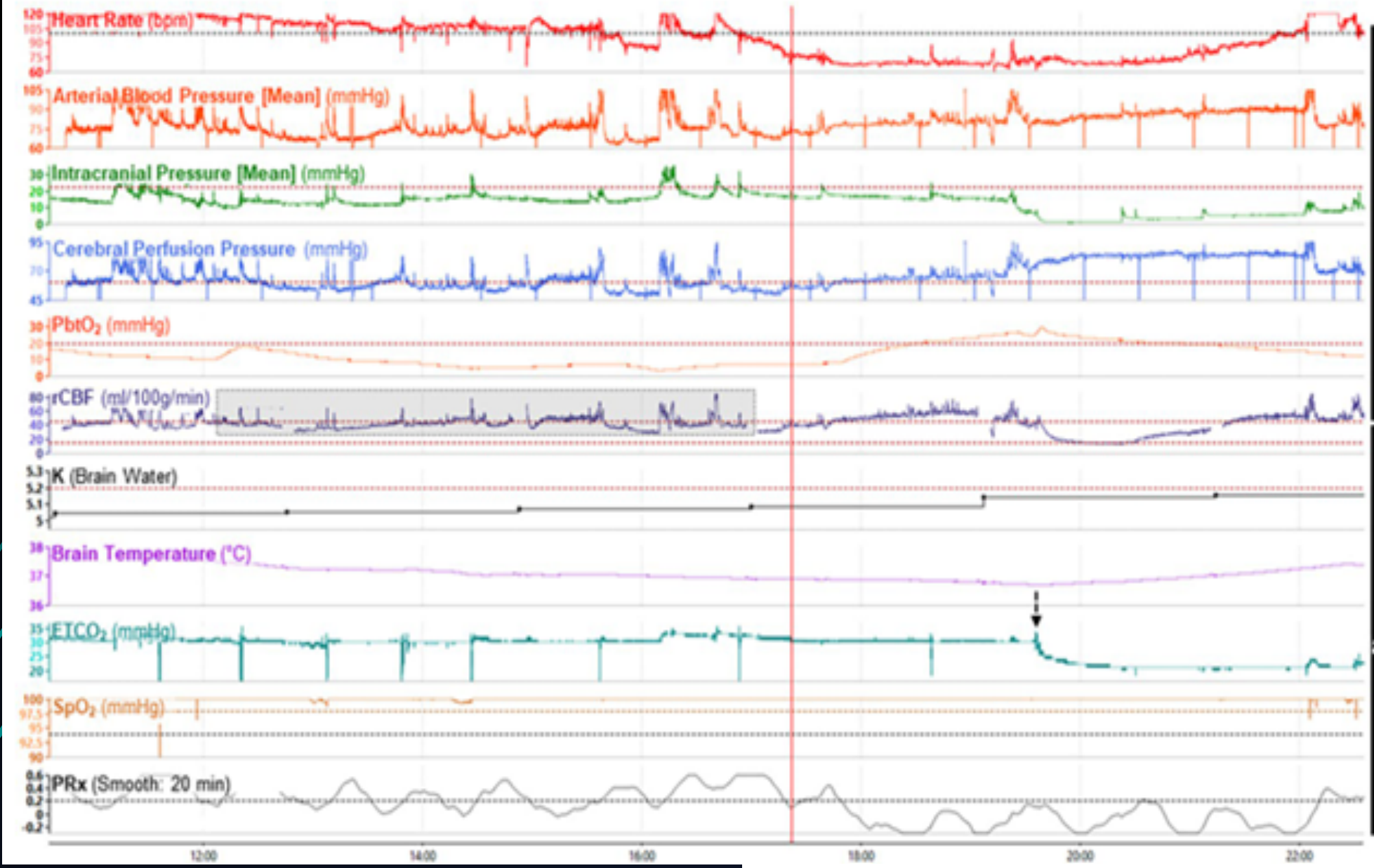
Case-based reasoning

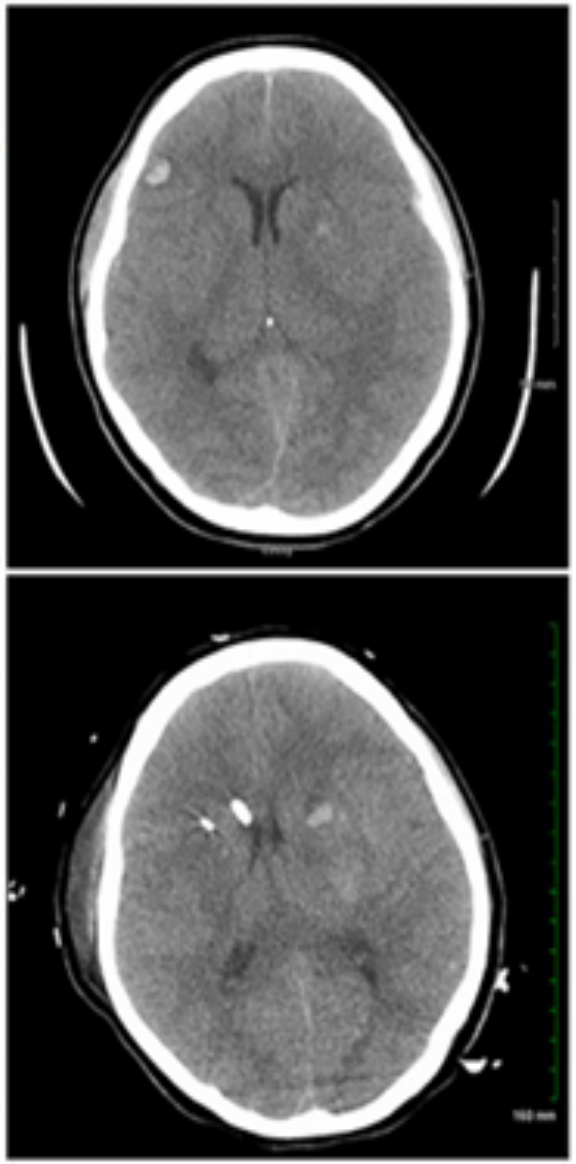
Optimal decision path finder (OPDF)

Machine learning + logistic regression

Fuzzy logic-based control system

DBN





Neurotherapeutics (2023) 20:1457–1471
https://doi.org/10.1007/s13311-023-01411-2

Management Strategies Based on Multi-Modality Neuromonitoring in Severe Traumatic Brain Injury





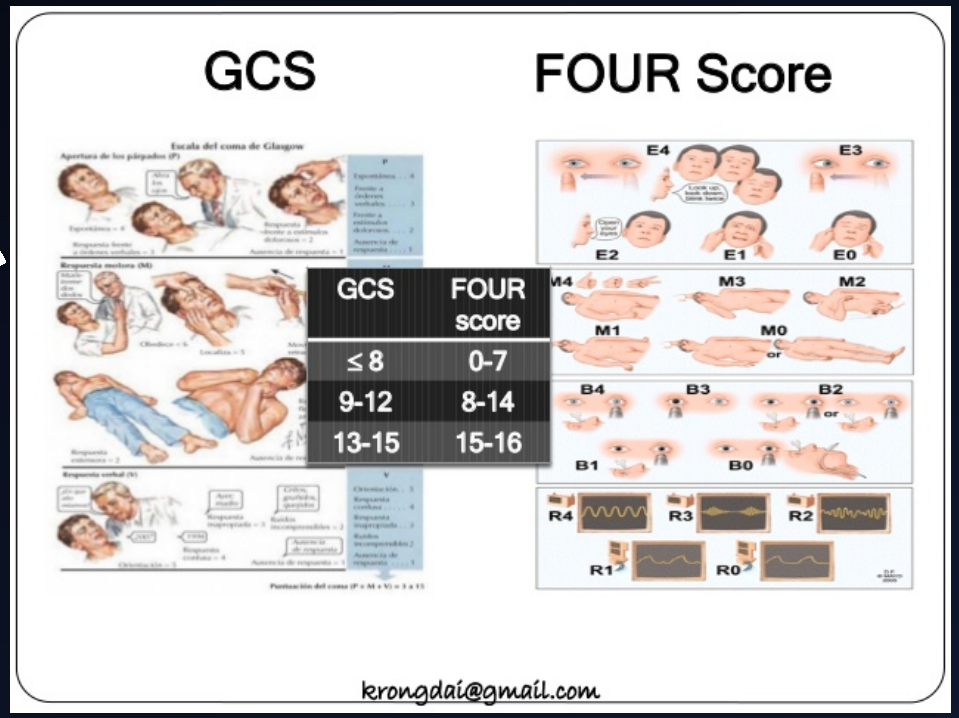
Klinické monitorování

- GCS
- Full Outline of UnResponsivenes (FOUR)
- Delirium



MRC scale	
0	complete paralysis
1	minimal contraction
2	active movement with gravity eliminated
3	weak contraction against gravity
4	active movement against gravity and resistance
5	normal strength

Simplified MRC scale	
0	complete paralysis
1	severe weakness (> 50% loss of strength)
2	slight weakness (< 50% loss of strength)
3	normal strength



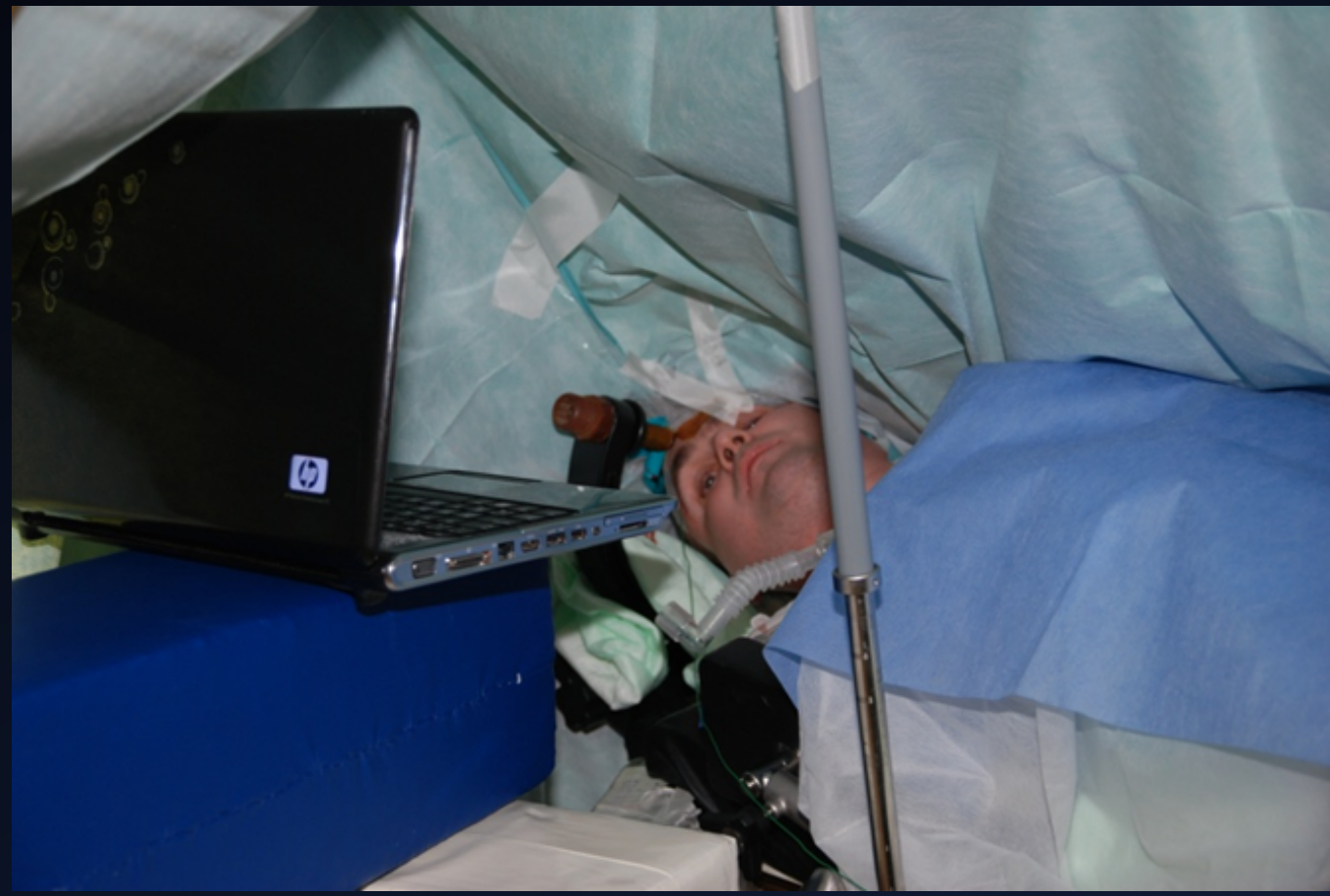
Component Tested	Score
Eye response	
Eyelids open or opened, tracking or blinking	4
Eyelids open but not tracking	3
Eyelids closed, but open to loud voice	2
Eyelids closed, but open to pain	1
Eyelids remain closed to pain	0
Motor response	
Thumbs-up, fist or peace sign	4
Localizing to pain	3
Flexion response to pain	2
Extension response to pain	1
No response or generalised myoclonus status	0
Brain stem reflexes	
Pupil and corneal reflexes present	4
One pupil wide and fixed	3
Pupil or corneal reflexes absent	2
Pupil and corneal reflexes absent	1
Absent pupil, corneal and cough reflex	0
Respiration	
Not intubated, regular breathing pattern	4
Not intubated, cheyne stokes breathing pattern	3
Not intubated, irregular breathing	2
Breathes above ventilator rate	1
Breathes at ventilator rate or apnea	0

Awake

- Anatomické intervence

Vs.

- Funkční intervence



Doporučení monitorací

- ICP
- CPP
- PRx
- $PbtO_2$
- Zobrazení

…

- TBI
- iCMP
- Krvácení
- SAK

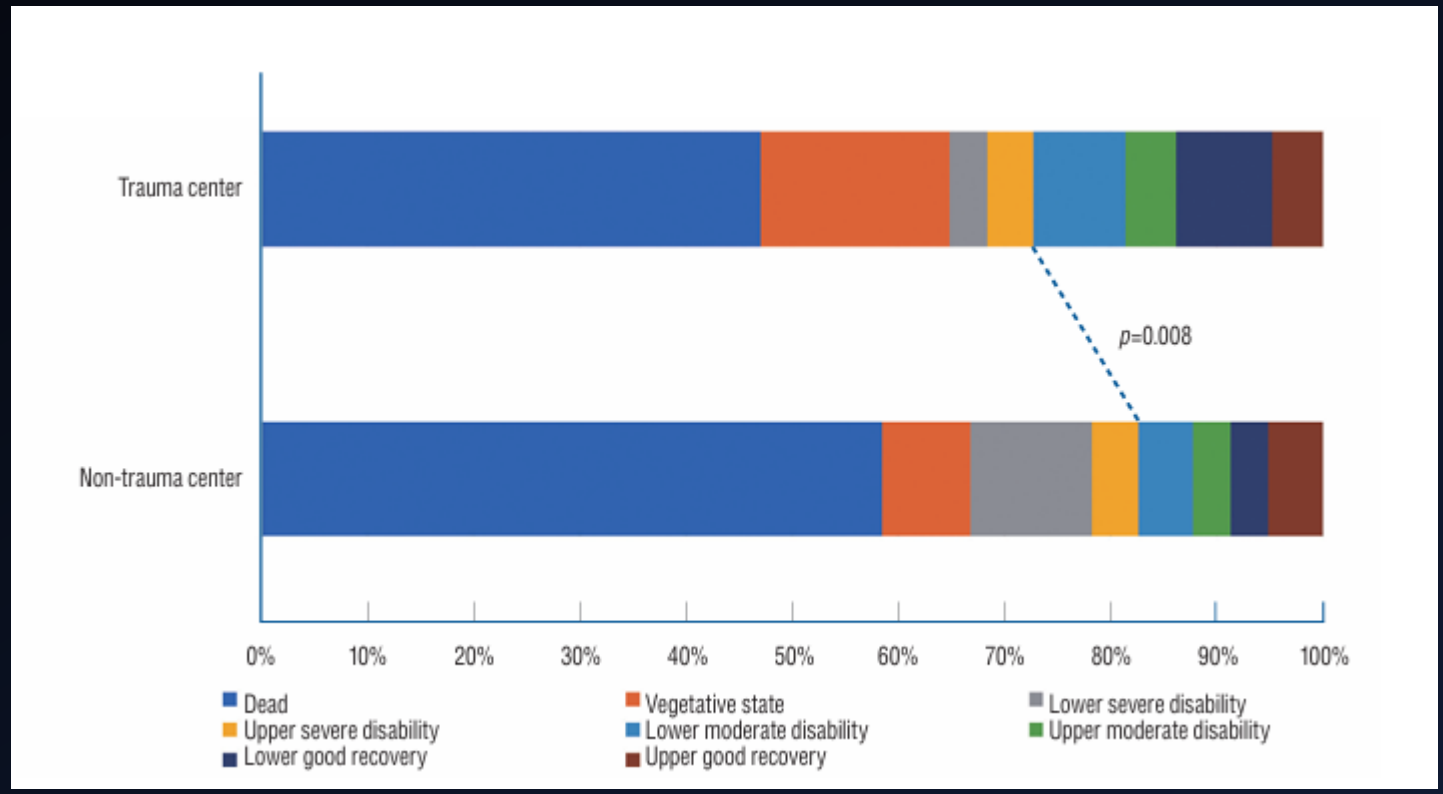
Topic section
Clinical evaluation
Systemic hemodynamics
Intracranial pressure and cerebral perfusion pressure
Cerebrovascular autoregulation
Systemic and brain oxygenation
Cerebral blood flow and ischemia
Electrophysiology
Cerebral metabolism
Glucose and nutrition
Hemostasis and hemoglobin
Temperature and inflammation
Biomarkers of cellular damage and degeneration
ICU processes of care
Multimodality monitoring informatics integration, display and analysis
Monitoring in emerging economies
Future directions and emerging technologies

Monitoring Brain and Spinal Cord Metabolism and Function*

Open Journal of Anesthesiology, 2014, 4, 131-152

	EEG‡	EP	MCD	SvjO2	PbtO2	SctO2 (NIRS)	rCBF (TDP)	lCBF (LDF)	TCD
Intraoperative neuromonitoring									
1. Neurosurgery									
Invasive spine or spinal cord surgery		SEP/MEP							
Deep or intermediate hypothermia for brain vascular neurosurgery		SEP/VEP AEP							
Normothermic brain vascular neurosurgery		SEP/VEP AEP							
Cortical brain tumour resection (meningioma and astrocytoma)									
Posterior fossa surgery*		SEP/AEP							
Epilepsy surgery**									
Awake surgery***									
Optic nerve, hypothalamic, pituitary gland, and diaphragma sellae surgery****		VEP							
Surgical peripheral nerve release		SEP/MEP							
2. Cardiac & vascular surgery									
Normothermic thoracic and thoracoabdominal aortic surgery		SEP/MEP							
Normothermic cardiac or vascular surgery									
Intermediate hypothermia for cardiac or vascular surgery		SEP/VEP							
Deep hypothermia for cardiac or vascular surgery§		SEP/VEP							
Carotid endarterectomy		SEP/VEP							
Intensive care unit									
Post-anoxic coma		SEP/VEP SEP/AEP							
Hypothermic coma		SEP/VEP SEP/AEP							
Intoxication and poisoning		SEP/VEP SEP/AEP							
Brain death		SEP/VEP SEP/AEP							
Non-epileptic seizures		SEP/VEP							
Status epilepticus		SEP/VEP							
Subarachnoid haemorrhage		SEP/VEP SEP/AEP							
Stroke (acute phase)		SEP/VEP SEP/AEP							
Trauma brain injury		SEP/VEP SEP/AEP							
Trauma spinal cord injury		SEP/MEP							

- Klinika
- ICP
- USG

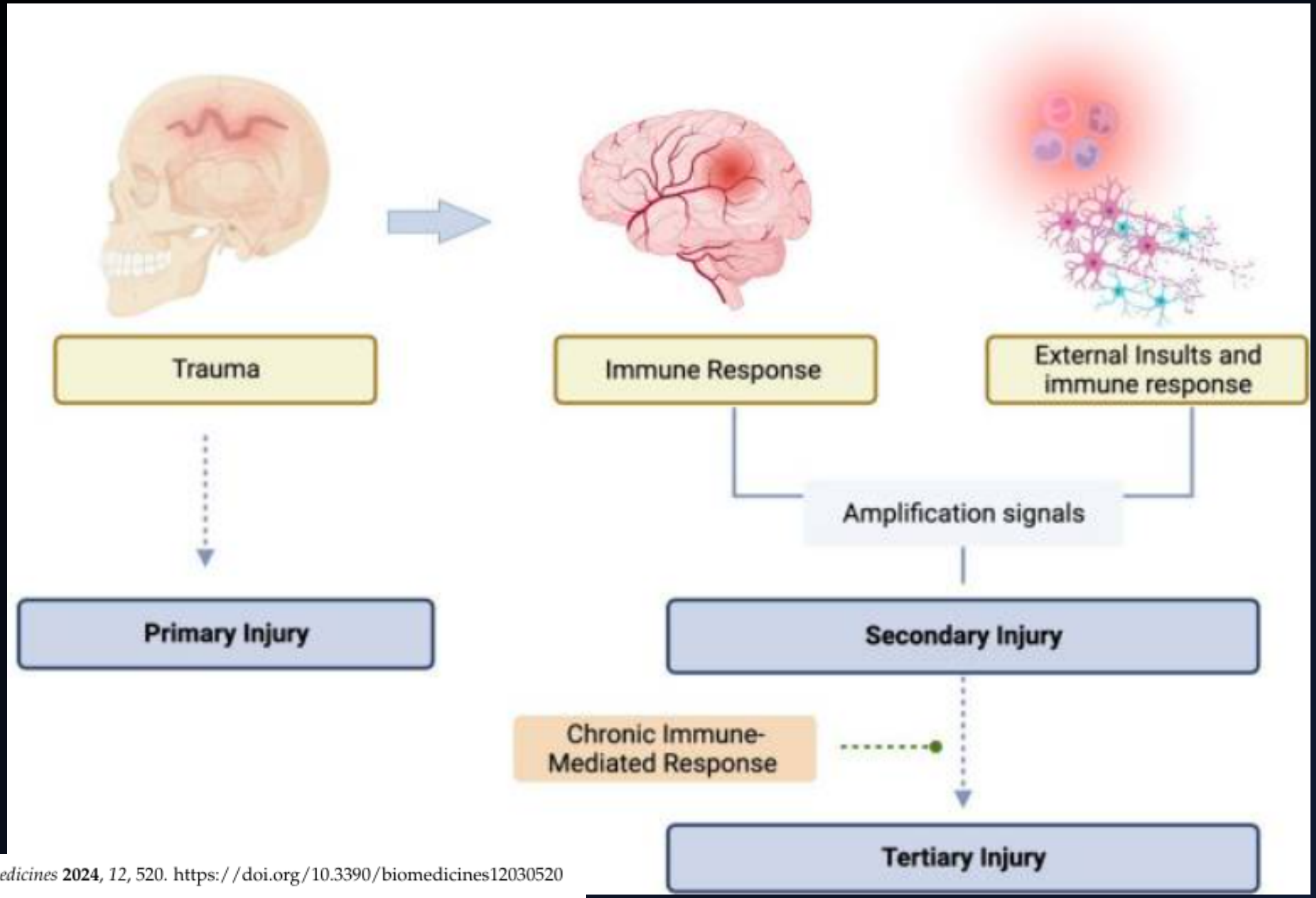


J Korean Neurosurg Soc 66 (1) : 63-71, 2023
https://doi.org/10.3340/jkns.2022.0163

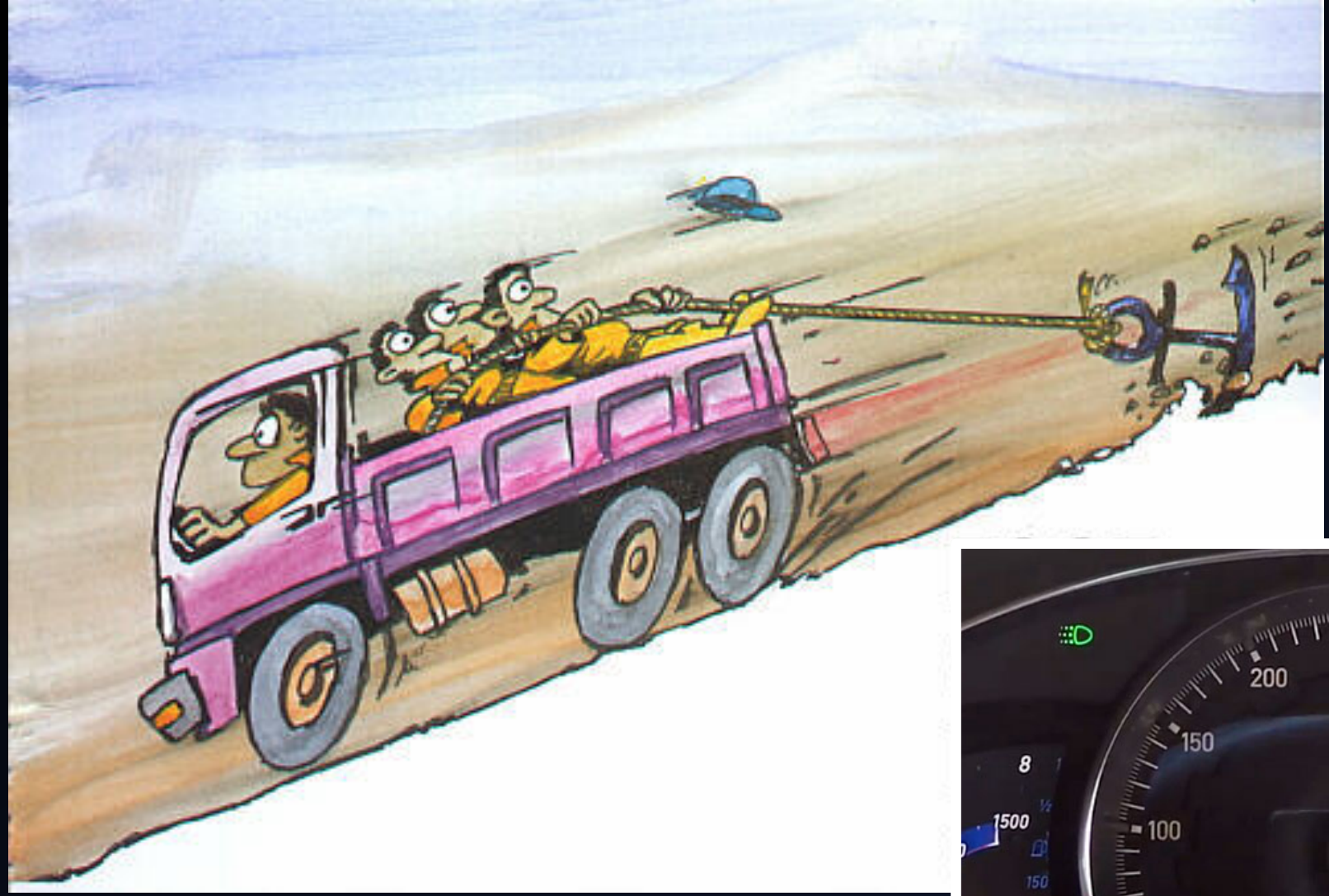
- Zlepšení fyziologických hodnot
- Evidence o dopadu na outcome chybí

- Neurointenzivní péče
- Protokoly



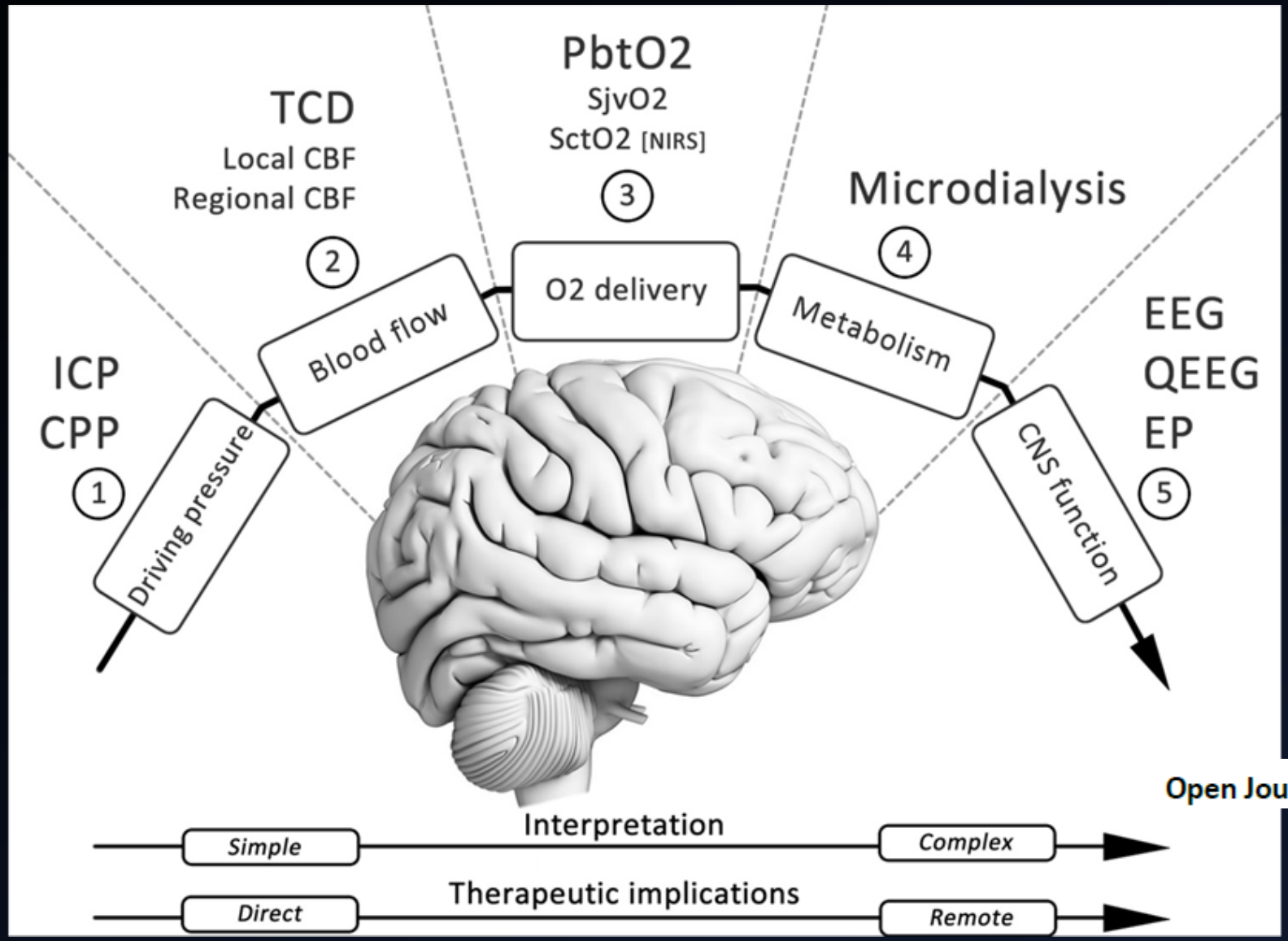


Biomedicines **2024**, *12*, 520. https://doi.org/10.3390/biomedicines12030520



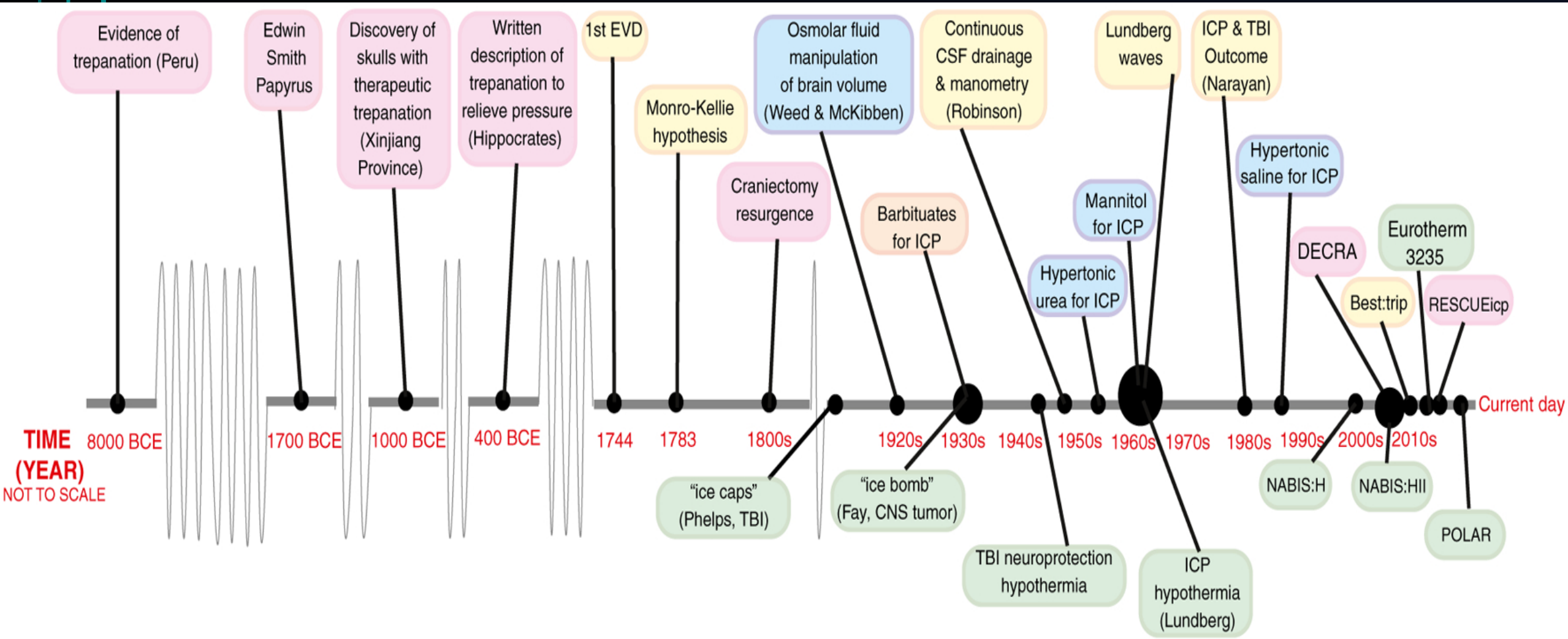



8
1500
150
100
50
0
km/h
Trip
607.7 km
351 km/h
D 6
200
250
300
350
400
450
500
État des pr
2.78 bar
34 °C
effective
2.95 bar
45 °C
19.5°C



Open Journal of Anesthesiology, 2014, 4, 131-152

Cerebral Edema in Traumatic Brain Injury: a Historical Framework for Current Therapy

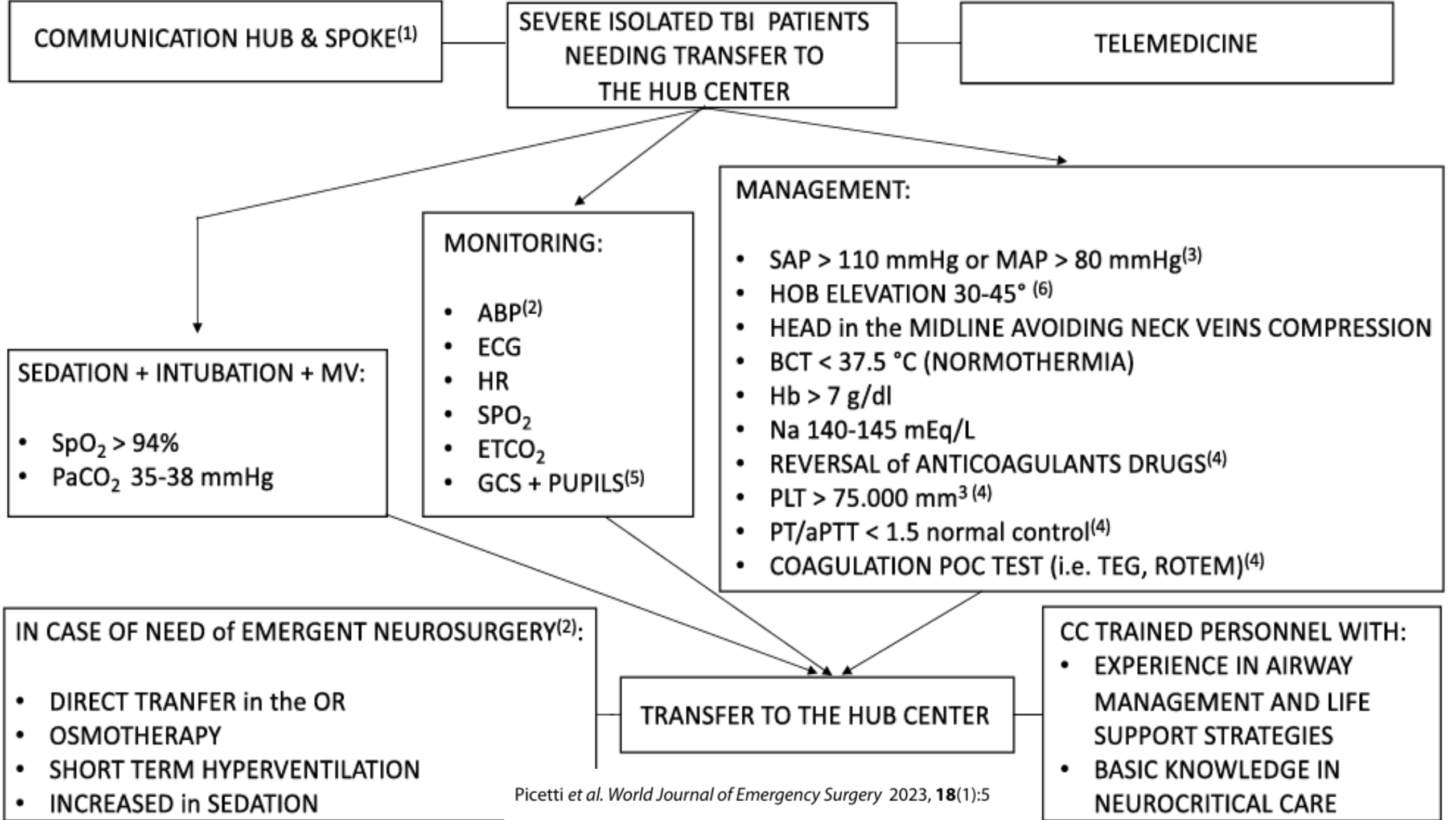


Curr Treat Options Neurol. 2020 March ; 22(3): . doi:10.1007/s11940-020-0614-x.

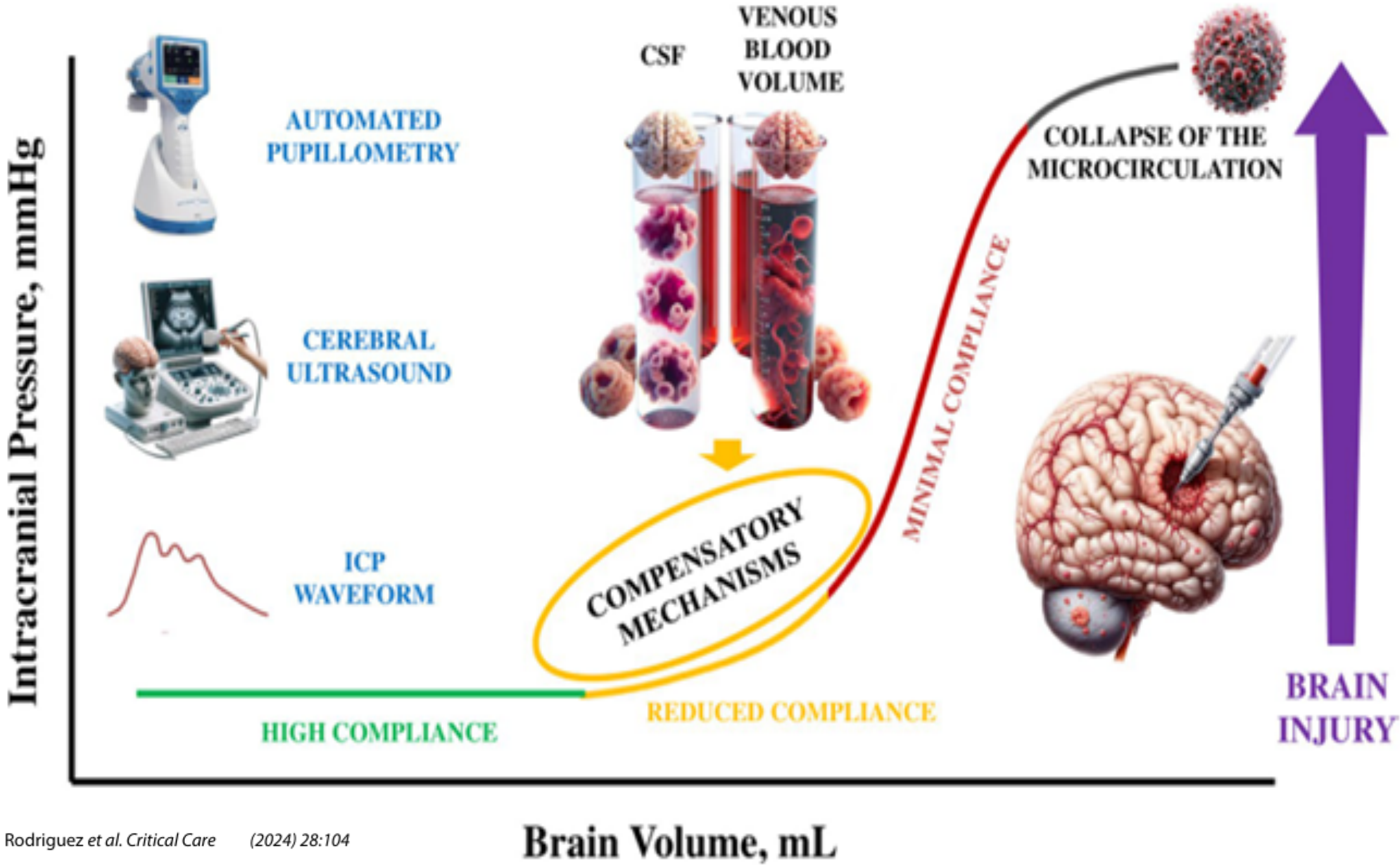
Table 1. Escalating options to treat elevated intracranial pressure.

Intervention	Effect	Pot. Benefit	Pot. Risk
(Deepening of) Analgosedation, Barbiturates	Decrease of brain metabolism and therefore oxygen consumption	Decrease in CBF, CBV and ICP	Adverse effects of long-term sedation, impaired neurological assessment
Osmotherapy with Mannitol	Reduction in brain tissue volume, increase in CBF	Decreases ICP, no improvement of tissue oxygenation	Fluid overload, osmotic diuresis leading to hypovolemia, hyperosmolarity, rebound brain edema
Osmotherapy with hypertonic saline	Reduction in brain tissue volume, increase in CBF	Decreases ICP, improvement of tissue oxygenation	Fluid overload, osmotic diuresis leading to hypovolemia, hyperosmolarity
CSF drainage	Allows for expansion of brain tissue by reducing CSF volume	Lowers ICP	Transcerebral ventricular drainage required, risk of ventriculitis, meningitis
Hyperventilation	Cerebral vasoconstriction leading to reduced CBV	Lowers ICP if autoregulation is intact	Reduction in CBF leading to brain tissue ischemia
Decompressive craniectomy	Allows for expansion of the edematous brain	Decreases ICP, may improve tissue perfusion	Aggravation of brain edema, unfavorable outcome after 6 months

ICP: Intracranial pressure, CBV: Cerebral blood volume, CBF: Cerebral blood flow, CSF: Cerebrospinal fluid.



Picetti *et al. World Journal of Emergency Surgery* 2023, **18**(1):5



Rodriguez *et al. Critical Care* (2024) 28:104

- Nihilismus
- Realismus

- Fyziologie
- Outcome



