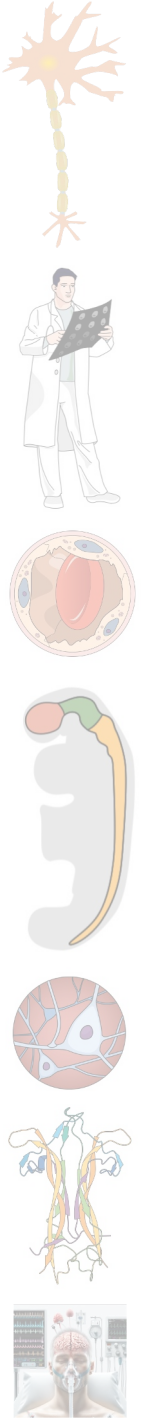


TRAUMATIC BRAIN INJURY: INITIAL MANAGEMENT

Fabio Silvio TACCONE
Brussels, Belgium



CONFLICT OF INTEREST



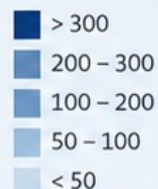
TRAUMATIC BRAIN INJURY: THE BURDEN

A. Global incidence

An estimated **50 million people** suffer from a TBI worldwide every year

>80%

occur in low- and middle-income countries



Estimated annual incidence of TBI (per 100 000 population)



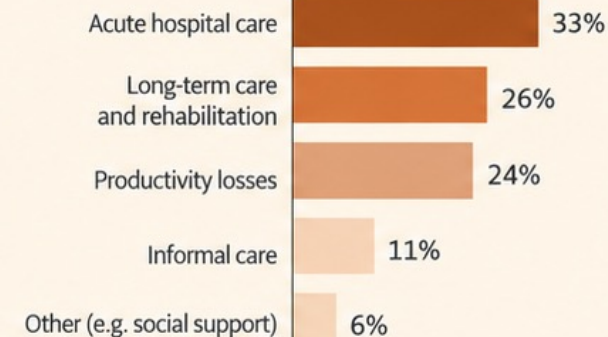
B. Economic impact

The annual global costs of care and consequences of TBI are up to

US\$400 billion



Major cost components



C. Impact across the lifespan

In developed countries, TBI increasingly affects the **elderly** and young children

Older adults



- Increasing incidence, mainly due to falls
- Higher mortality and disability
- Greater healthcare and long-term care needs

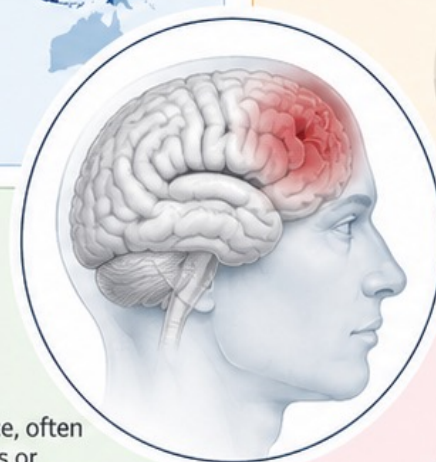
Growing proportion of TBI in patients ≥ 65 years

Children <4 years



- High incidence, often related to falls or non-accidental injury
- Risk of long-term neurodevelopmental consequences

TBI is a leading cause of death and disability in children



D. Mortality and hospitalisation in Europe



57 000

TBI-related deaths occur in the EU-28 every year



1.5 million

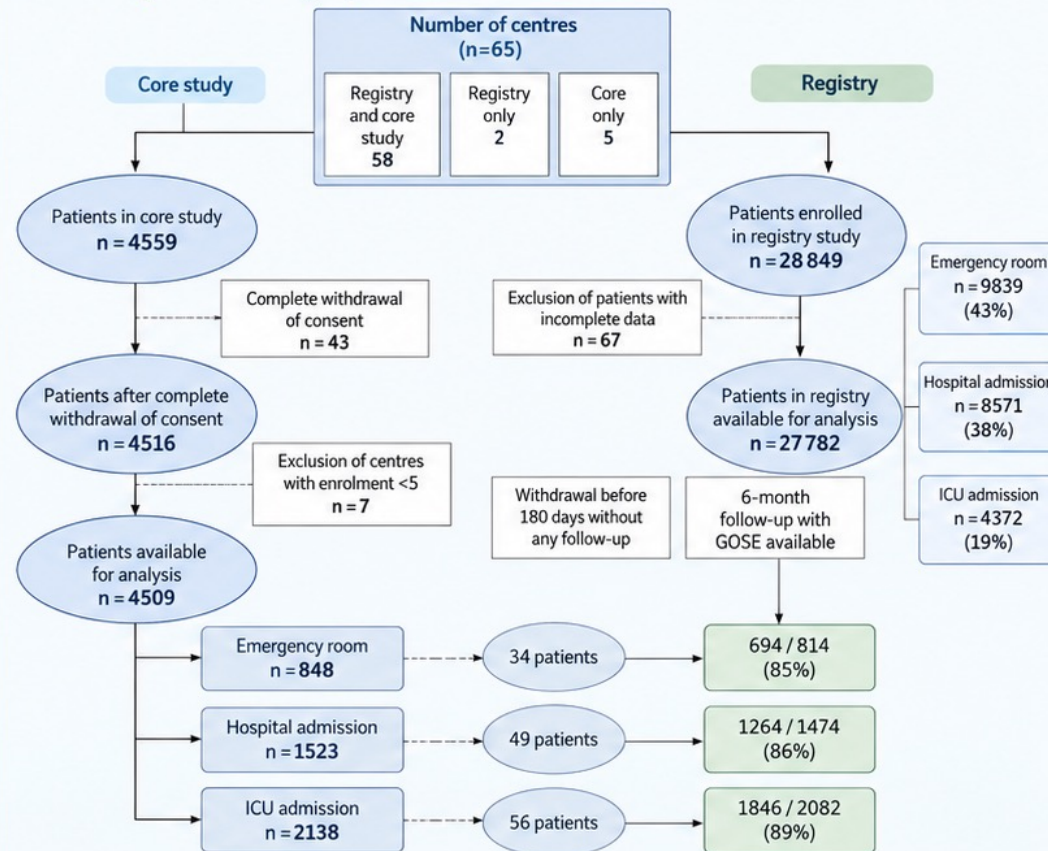
TBI-related hospitalisations occur in the EU-28 every year

Case-mix, care pathways, and outcomes in patients with traumatic brain injury in CENTER-TBI: a European prospective, multicentre, longitudinal, cohort study

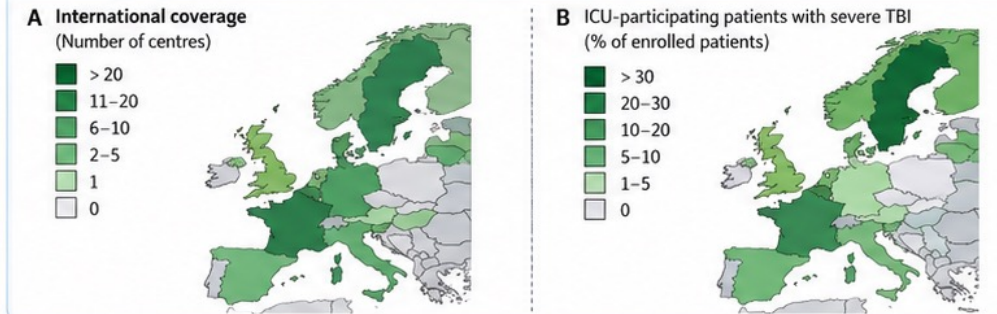


Ewout W Steyerberg, Eveline Wiegers*, Charlie Sewalt*, Andras Buki, Giuseppe Citerio, Véronique De Keyser, Ari Ercole, Kevin Kunzmann, Linda Lanyon, Fiona Lecky, Hester Lingsma, Geoffrey Manley, David Nelson, Wilco Peul, Nino Stocchetti, Nicole von Steinbüchel, Thijs Vande Vyvere, Jan Verheyden, Lindsay Wilson, Andrew I R Maas*, David K Menon,* and the CENTER-TBI Participants and Investigators†

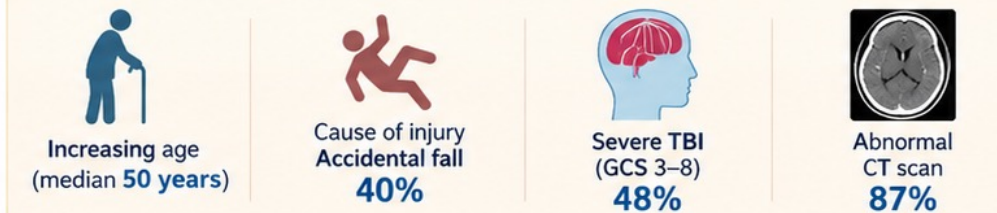
A. Study flow and population



B. Geographic distribution of centres and participants



C. Key patient characteristics (overall population)

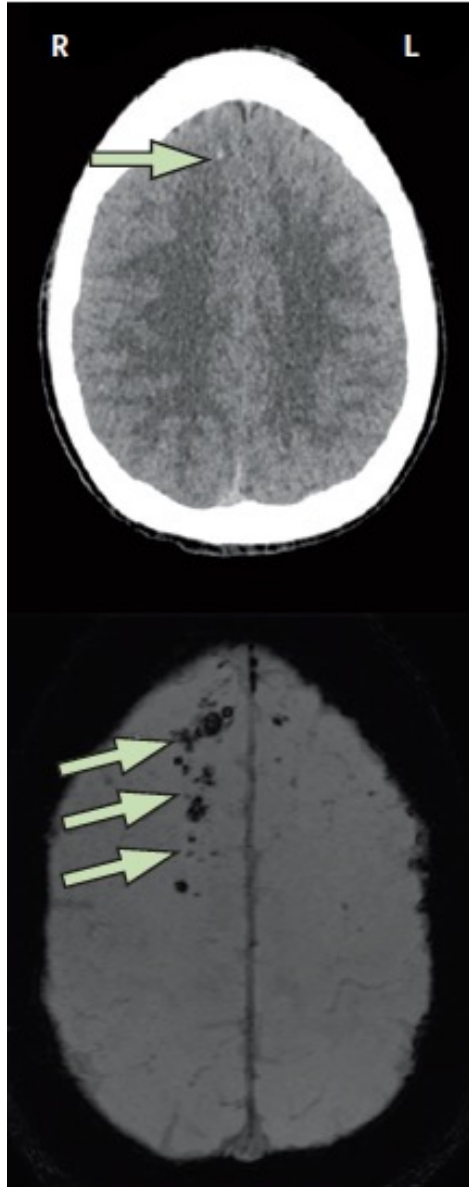


D. Acute management and outcomes

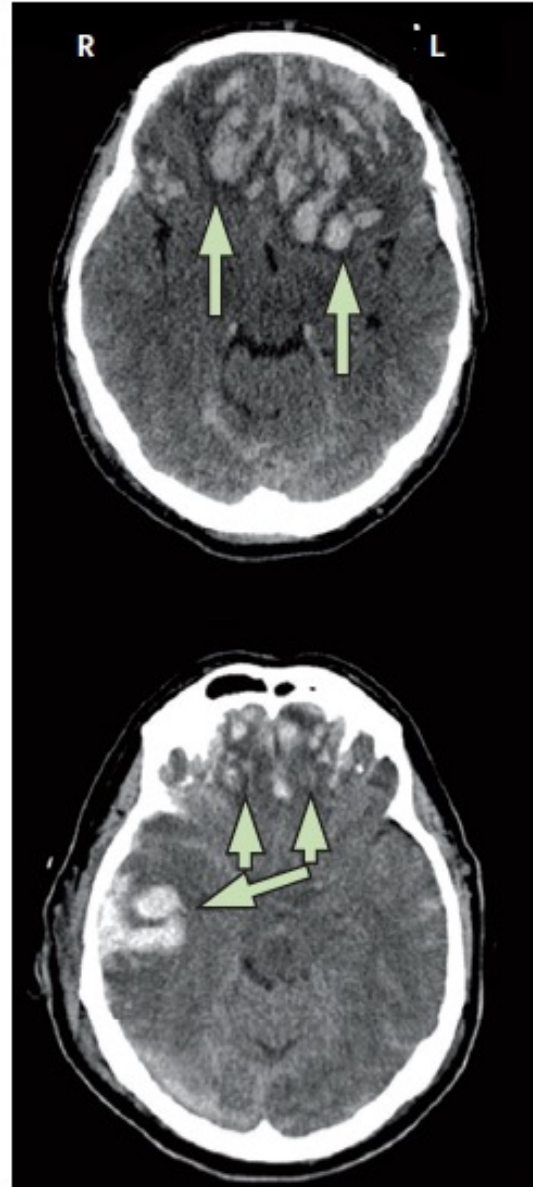




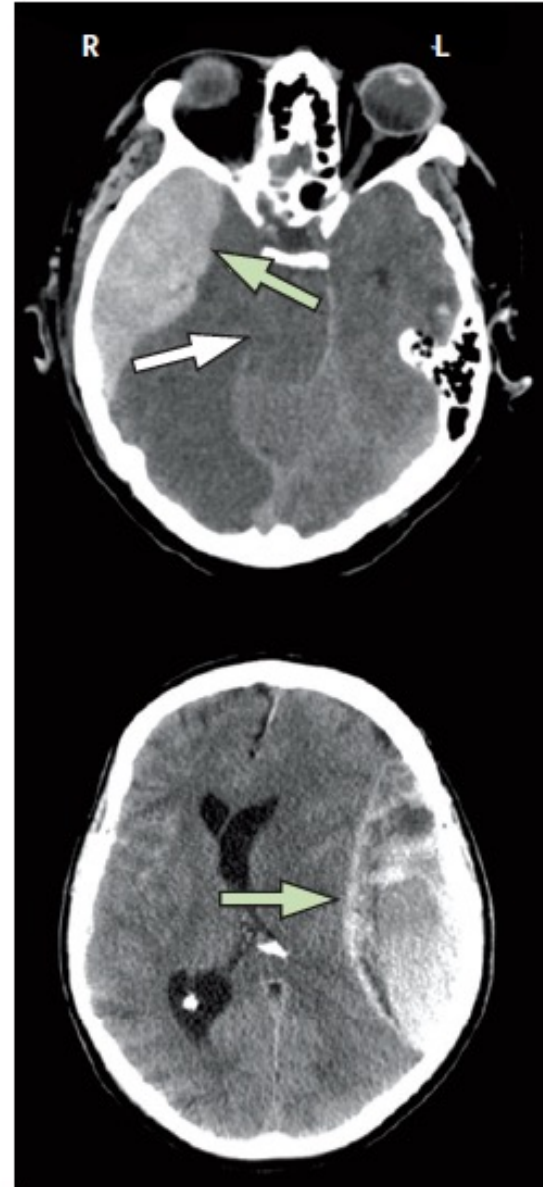
A Sheared brain

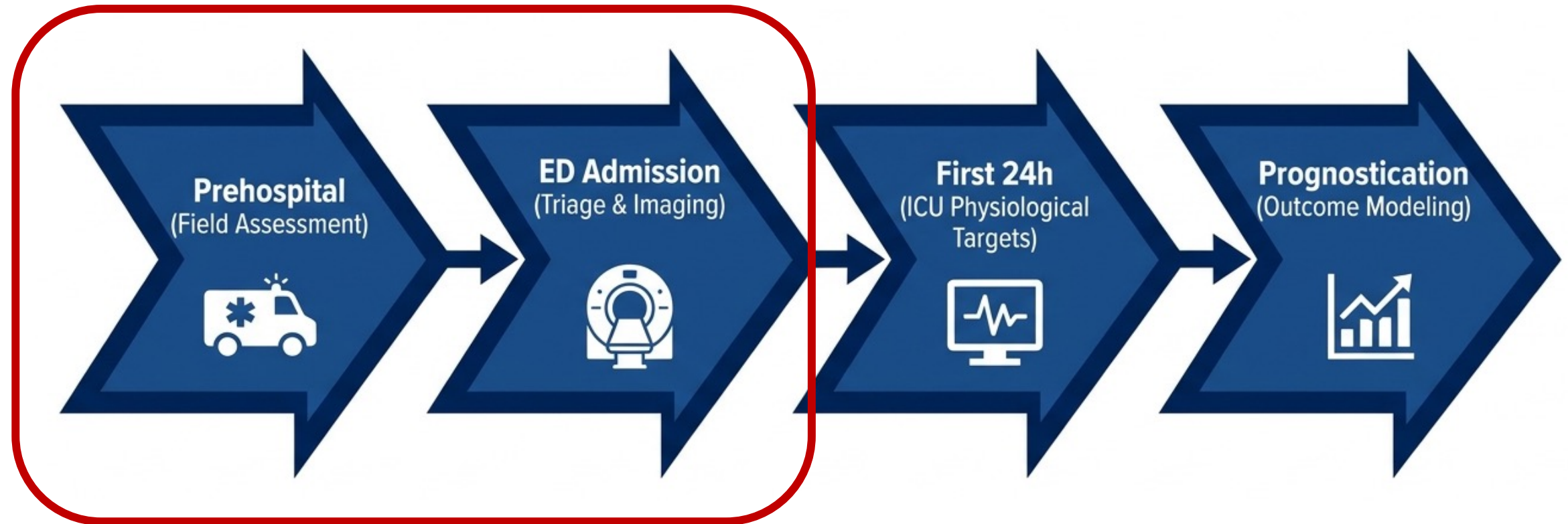
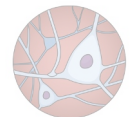
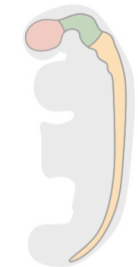
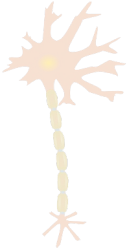


B Bruised brain



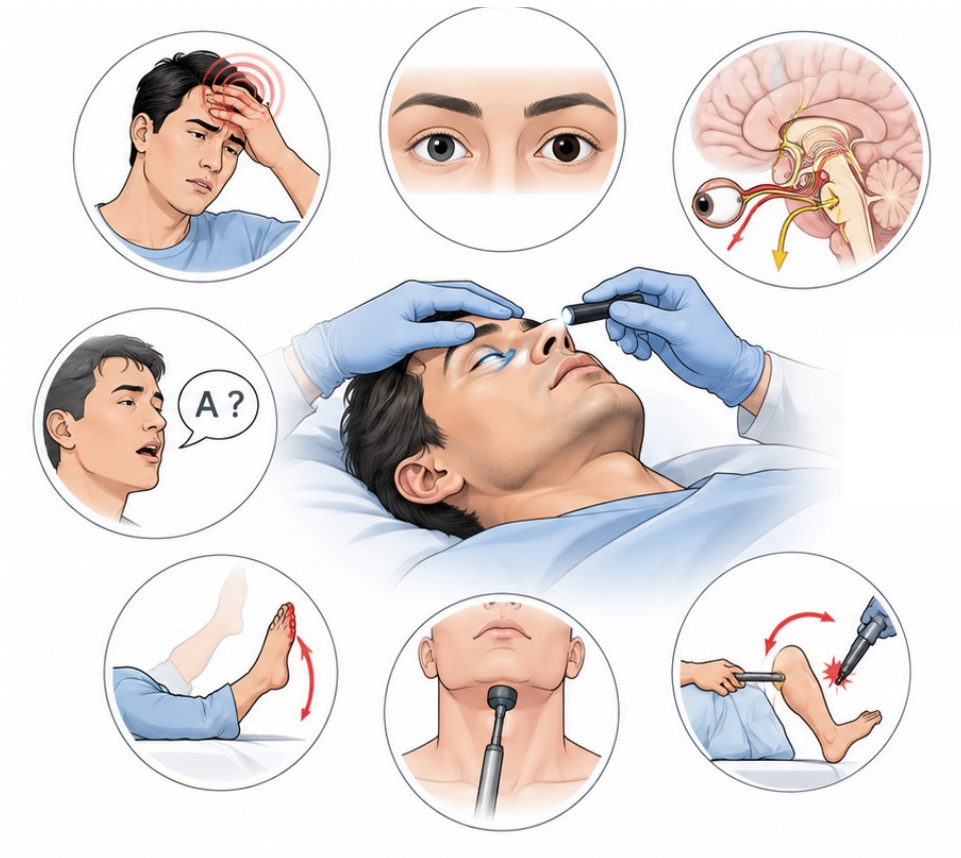
C Brain under pressure





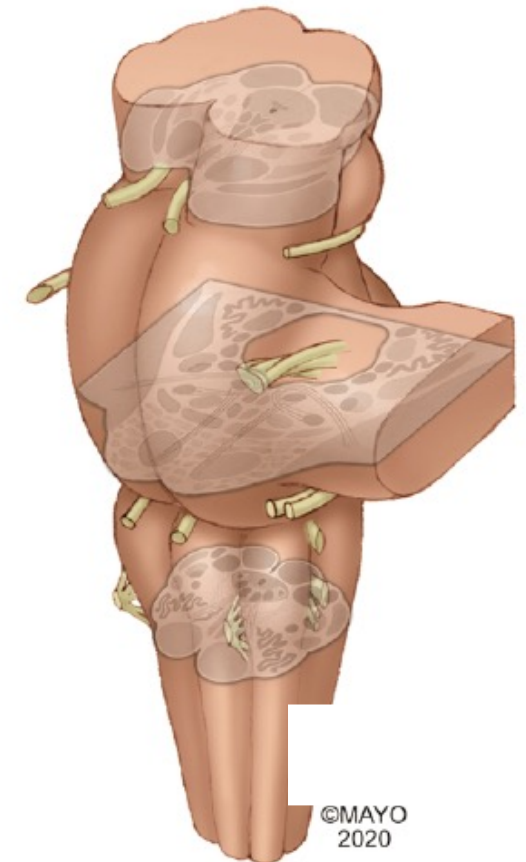
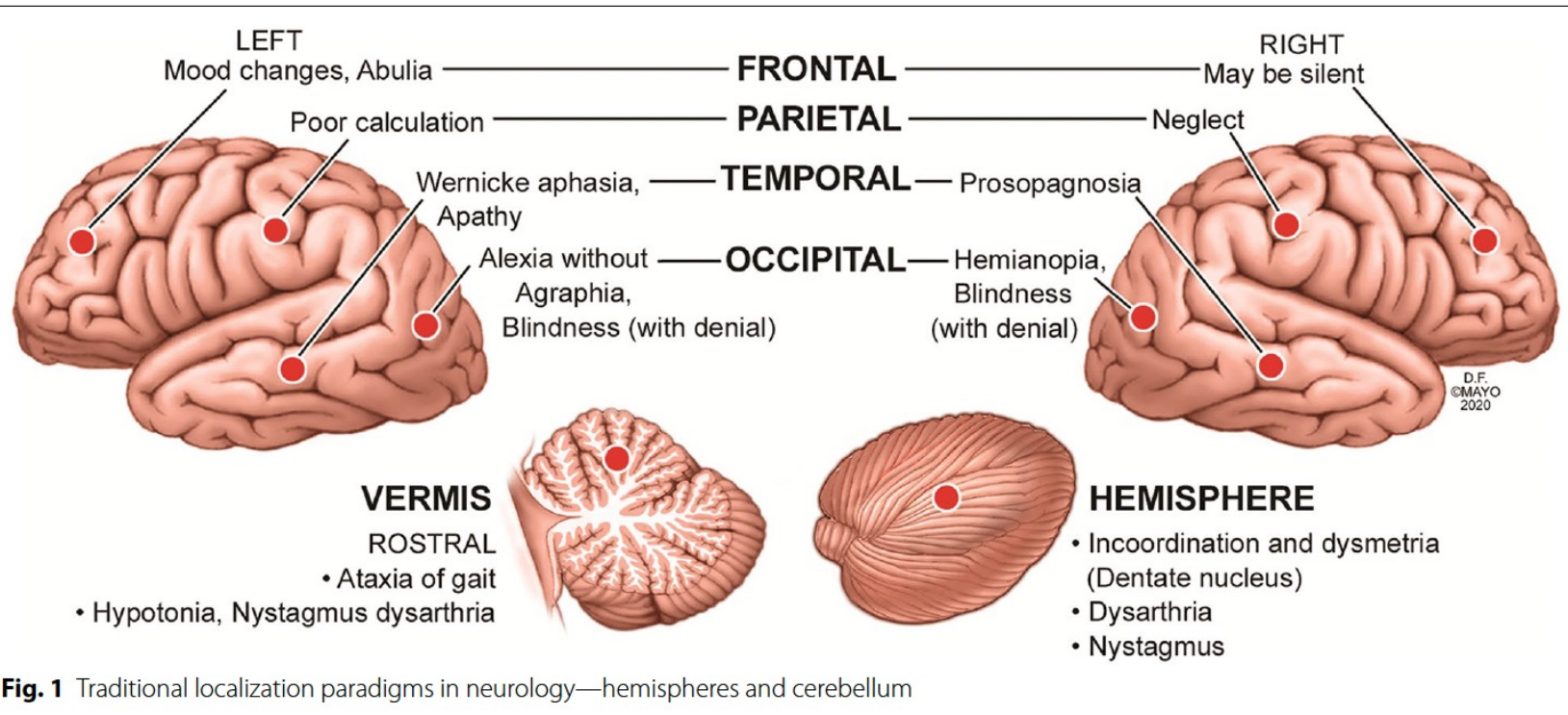
FIRST ASSESSMENT

CLINICAL EXAMINATION



The neurologic consultation: pointers and takeaways for intensivists

Eelco F. M. Wijdicks* 



CLINICAL EXAMINATION

Eye opening (E)

Score 1–4



1 No eye opening



2 To pain



3 To speech



4 Spontaneous

Verbal response (V)

Score 1–5



1 No verbal response



2 Incomprehensible sounds



3 Inappropriate words



4 Confused conversation



5 Oriented

Motor response (M)

Score 1–6



1 No motor response



2 Extension to pain



3 Abnormal flexion to pain



4 Withdrawal to pain



5 Localises pain



6 Obeys commands

Glasgow Coma Scale (GCS)

Sum of scores (3–15)



1 – 4



1 – 5



1 – 6

Total
GCS
3 – 15

GCS 13 – 15
Mild TBI



GCS 9 – 12
Moderate TBI



GCS 3 – 8
Severe TBI



CLINICAL EXAMINATION

GCS-P

Pupil reactivity score (subtract from total GCS)		Score
	Both pupils reactive to light	0
	One pupil unreactive to light	1
	Both pupils unreactive to light	2



For total GCS, subtract pupil reactivity score from the calculated GCS

Glasgow Coma Scale (GCS)

Sum of scores (3–15)

	E	1 – 4
	V	1 – 5
	M	1 – 6

Total
GCS
3 – 15

GCS 13 – 15
Mild TBI



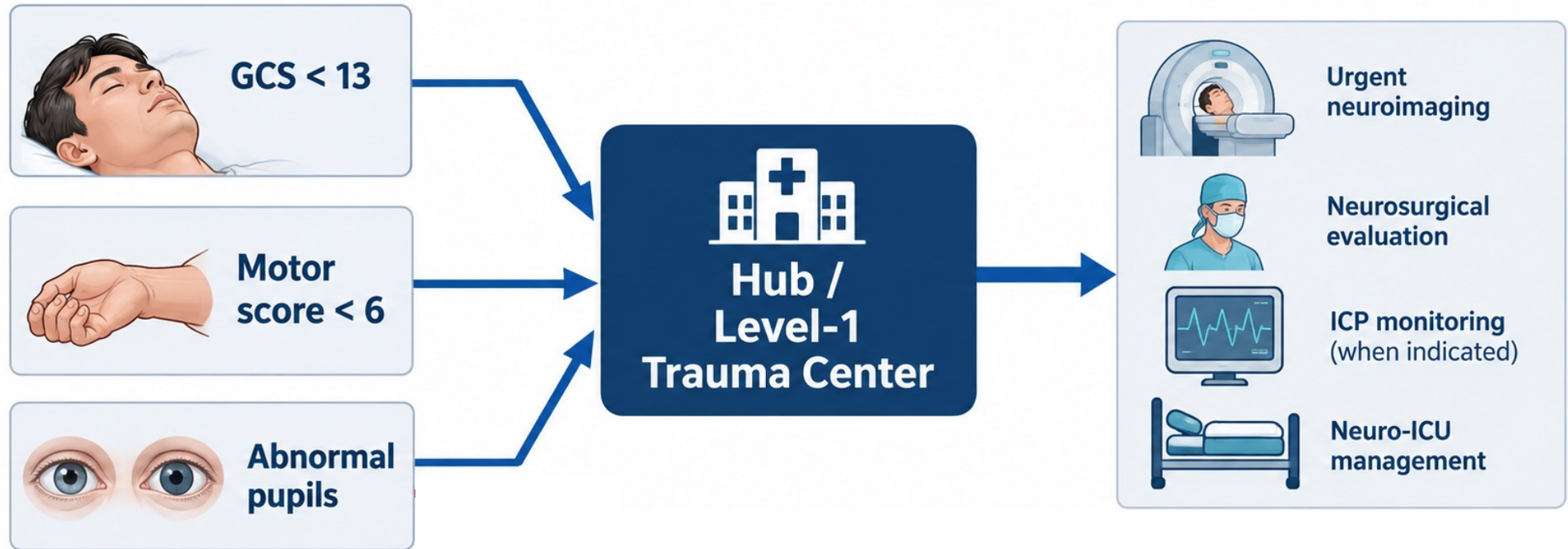
GCS 9 – 12
Moderate TBI



GCS 3 – 8
Severe TBI



CLINICAL EXAMINATION: TRIAGE





Tarek Sharshar
Giuseppe Citerio
Peter J. D. Andrews
Arturo Chiericato
Nicola Latronico
David K. Menon
Louis Puybasset
Claudio Sandroni
Robert D. Stevens

Neurological examination of critically ill patients: a pragmatic approach. Report of an ESICM expert panel

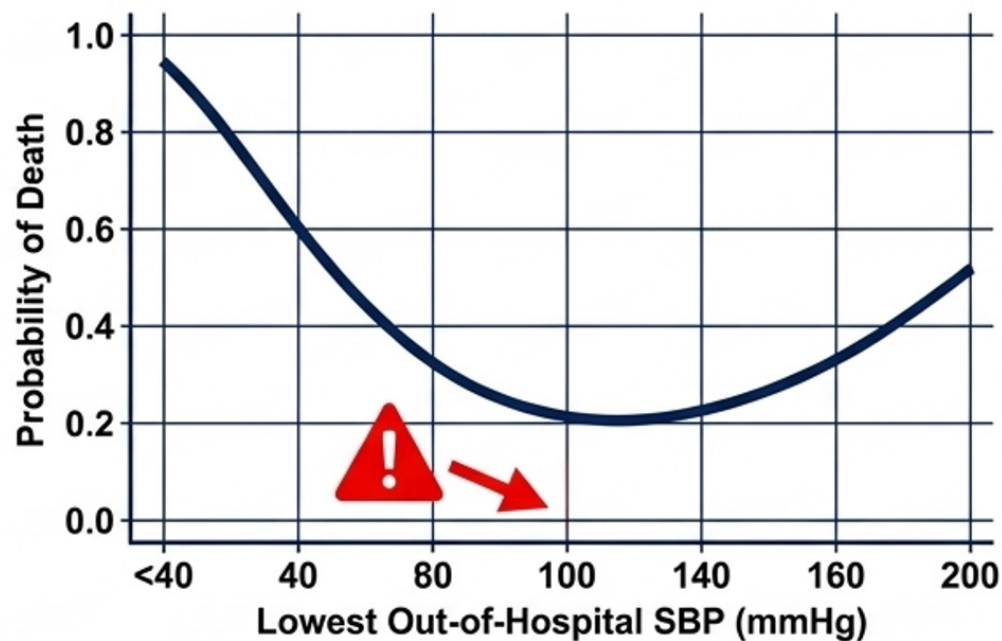
Intensive Care Med (2014) 40:484–495
DOI 10.1007/s00134-014-3214-y

- ✓ **Clinical examination is not “specific”**
- ✓ **Subtle alterations are not detectable by non-neurologists**
- ✓ **Drug Intoxications**
- ✓ **Other confounders ...**

EARLY INTERVENTIONS: SEVERE TBI

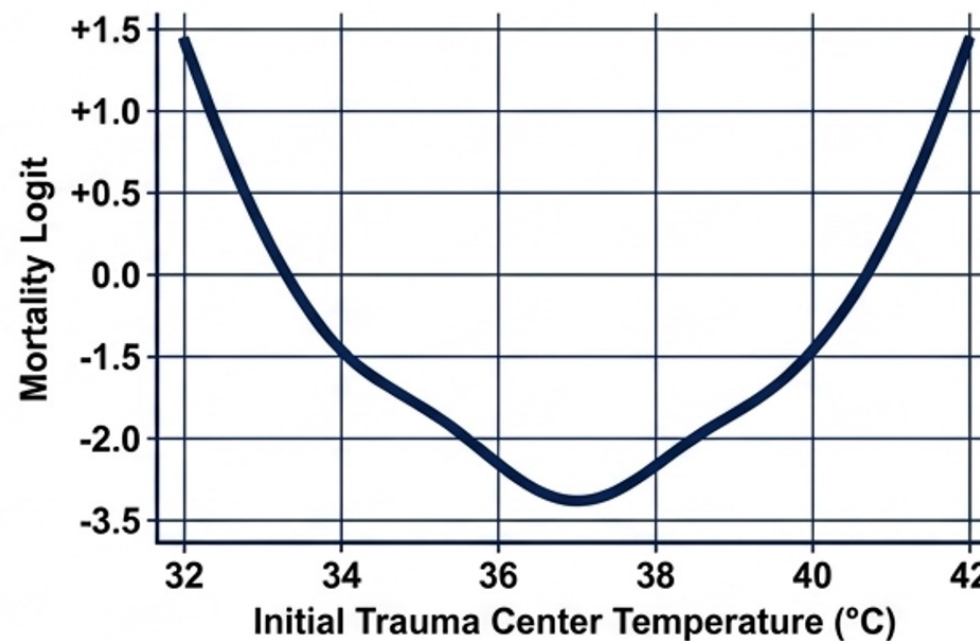
Strict SpO₂ > 90%

Avoid Hypotension



Target SBP > 100–110 mmHg

Maintain Euthermia



Maintain Euthermia
(avoid hyper/hypothermia)

EARLY INTERVENTIONS: SEVERE TBI

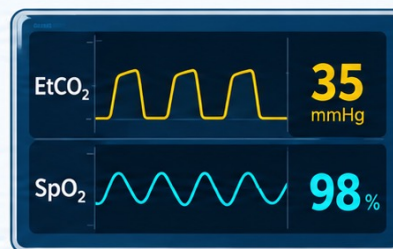
Airway / Breathing

Rapid induction sequence (RSI)

-  Induction agent (e.g. etomidate or ketamine)
-  Neuromuscular blocker (e.g. rocuronium)



After intubation



etCO₂ monitoring



Circulation



Saline solutions

Early vasopressors



Norepinephrine



Target

MAP ≈ 90 mmHg

(≥ 80–90 mmHg)

Continuous sedation (propofol > midazolam)



Propofol
(preferred)



Midazolam
(alternative)



Effects of balanced solution on short-term outcomes in traumatic brain injury patients: a secondary analysis of the BaSICS randomized trial

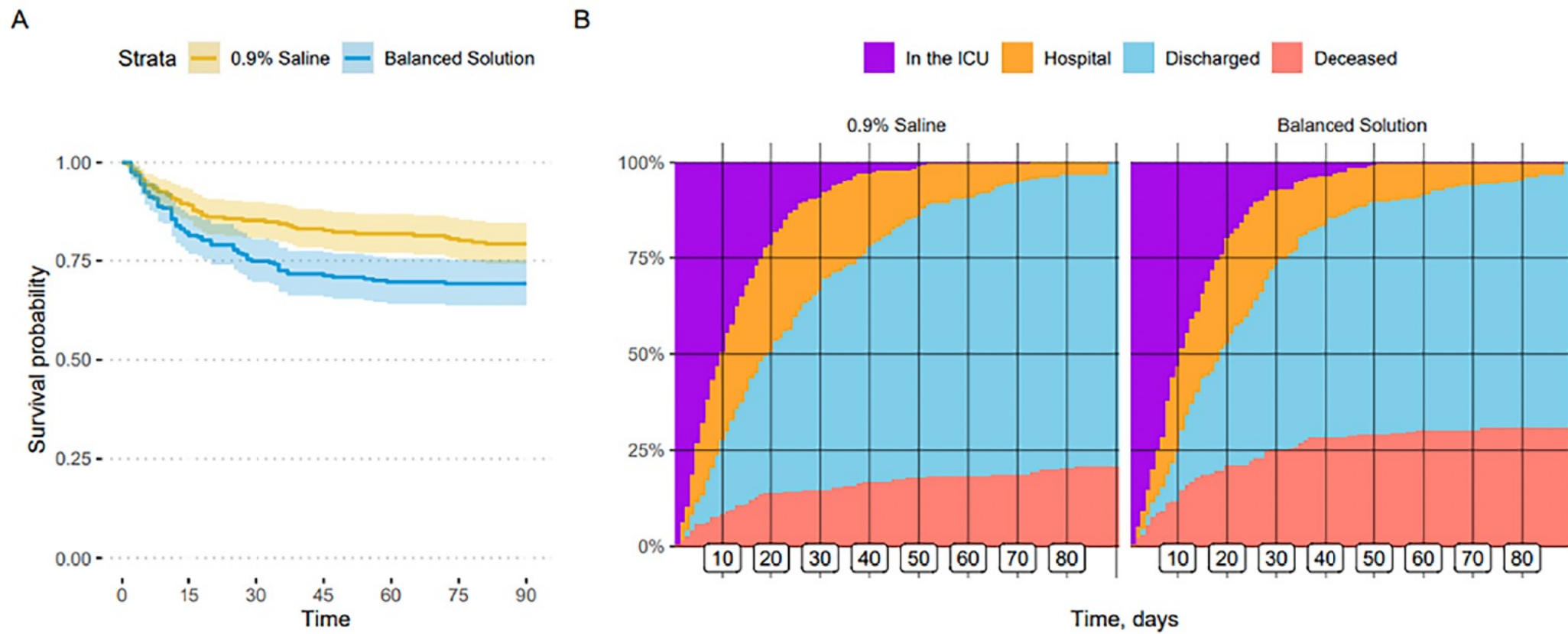


Figure 2 - (A) Survival curves for included patients, stratified according to intervention arm. (B) Patient status over time up to 90 days (only the first intensive care unit admission is considered); each vertical line represents 10-day intervals.

ICU - intensive care unit.

Saline or Albumin for Fluid Resuscitation in Patients with Traumatic Brain Injury

The SAFE Study Investigators*

Outcome	Albumin Group	Saline Group	Relative Risk (95% CI)	P Value
All patients				
Deaths — no./total no. (%)				
Within 28 days	61/231 (26.4)	36/229 (15.7)	1.68 (1.16–2.43)	0.005
Within 6 mo	68/221 (30.8)	40/217 (18.4)	1.67 (1.18–2.35)	0.003
Within 12 mo	69/220 (31.4)	40/216 (18.5)	1.69 (1.20–2.38)	0.002
Within 24 mo	71/214 (33.2)	42/206 (20.4)	1.63 (1.17–2.26)	0.003
Favorable score on the GOS-e at 24 mo	96/203 (47.3)	120/198 (60.6)	0.78 (0.65–0.94)	0.007
Survivors at 24 mo	96/132 (72.7)	120/156 (76.9)	0.95 (0.83–1.08)	0.41
Patients with a GCS score of 3–8				
Deaths — no./total no. (%)				
Within 28 days	55/160 (34.4)	30/158 (18.9)	1.83 (1.23–2.71)	0.002
Within 6 mo	60/154 (38.9)	32/149 (21.5)	1.81 (1.26–2.61)	0.001
Within 12 mo	61/153 (39.9)	32/149 (21.5)	1.86 (1.29–2.67)	0.001
Within 24 mo	61/146 (41.8)	32/144 (22.2)	1.88 (1.31–2.70)	<0.001



Effect of Continuous Infusion of Hypertonic Saline vs Standard Care on 6-Month Neurological Outcomes in Patients With Traumatic Brain Injury

The COBI Randomized Clinical Trial

B Kaplan-Meier estimates of the unadjusted probability of death at 6 mo (secondary end point)

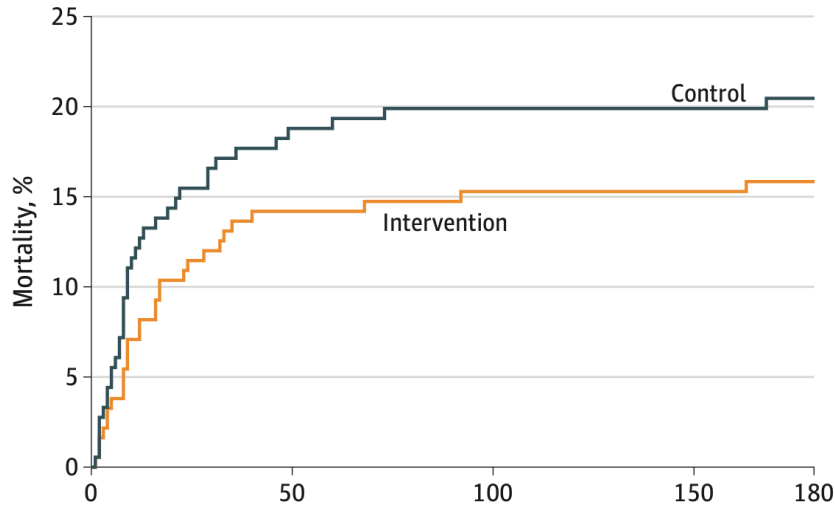


Figure 3. Outcomes at 6 Months

A GOS-E score at 6 mo (primary end point)

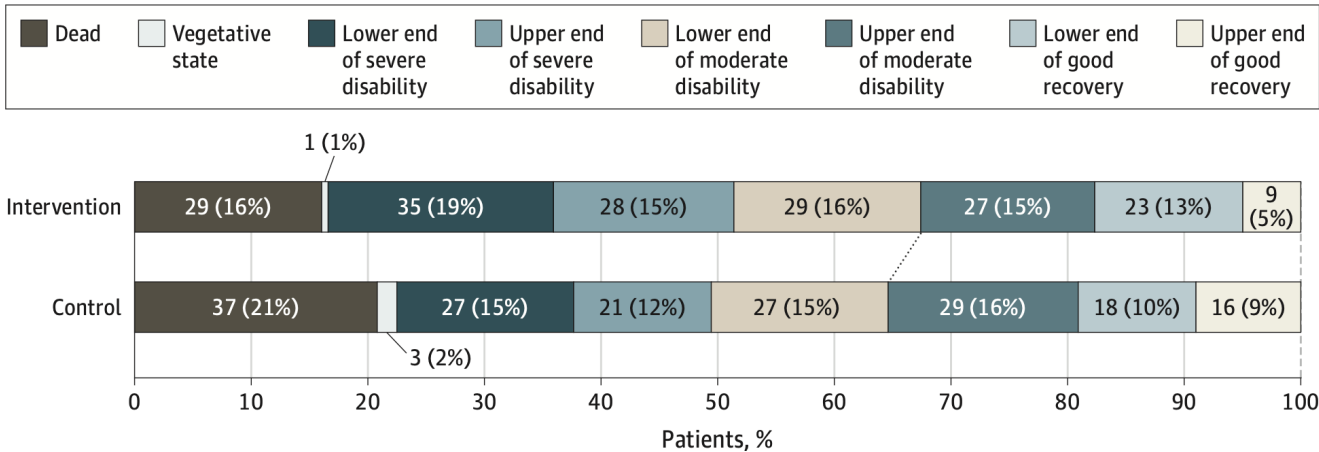


Table 2. Secondary Outcomes

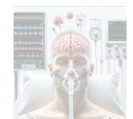
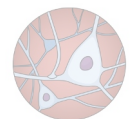
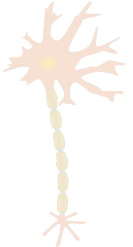
Outcomes	Intervention (n = 185)	Control (n = 185)	Absolute difference (95% CI) ^a	Odds ratio (95% CI)
Good neurological outcomes, No./total (%) ^b				
At 3 mo	62/175 (35.4)	53/176 (30.1)	5.31 (−4.49 to 15.12)	1.27 (0.79-2.06)
At 6 mo	59/181 (32.6)	63/178 (35.4)	−2.80 (−12.59 to 7.00)	0.85 (0.53-1.36)

Prehospital Guidelines for the Management of Traumatic Brain Injury – 3rd Edition

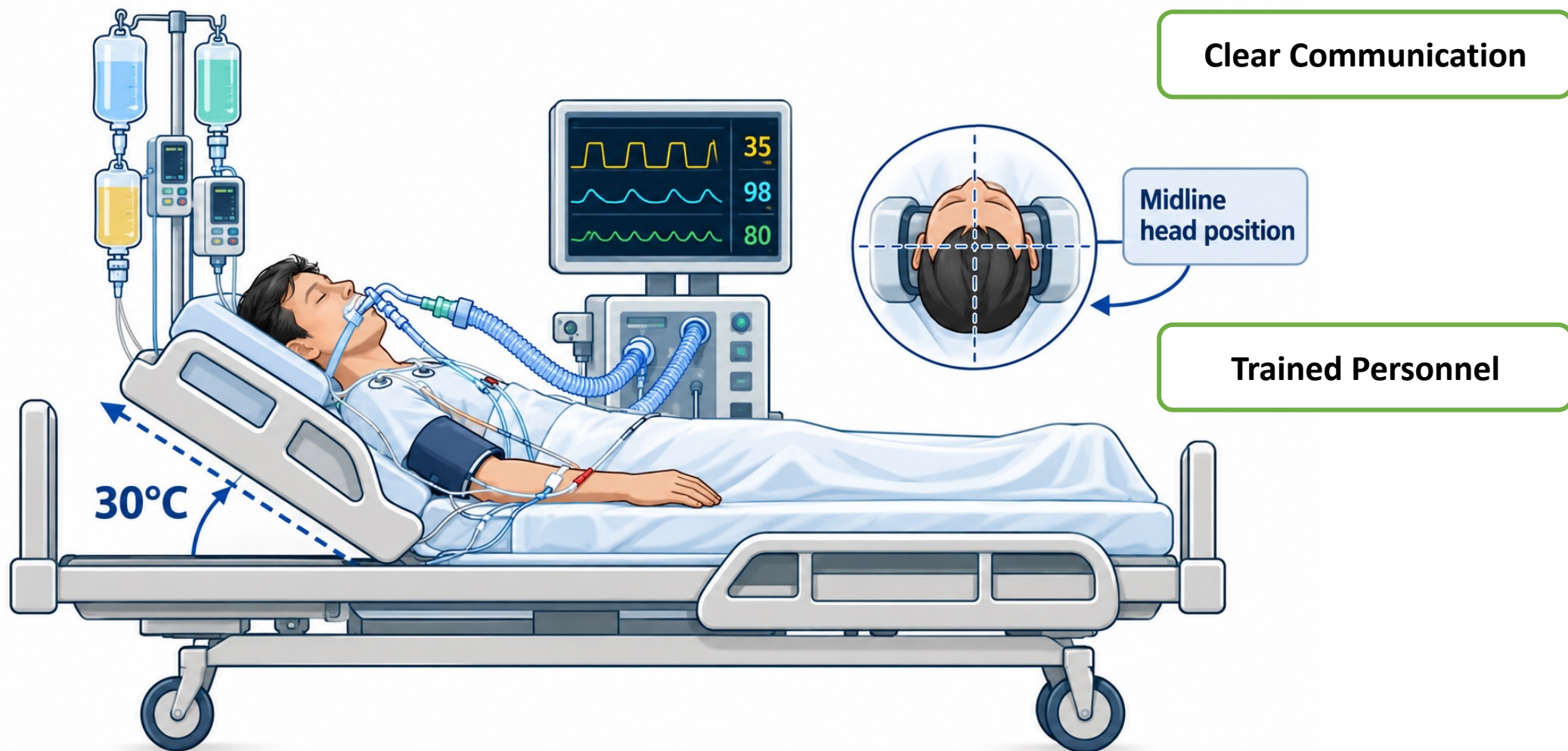
Al Lulla^a, Angela Lumba-Brown^b , Annette M. Totten^c, Patrick J. Maher^d, Neeraj Badjatia^e, Randy Bell^f, Christina T. J. Donayri^g, Mary E. Fallat^h, Gregory W. J. Hawrylukⁱ, Scott A. Goldberg^j, Halim M. A. Hennes^k, Steven P. Ignell^b, Jamshid Ghajar^l, Brian P. Krzyzaniak^m, E. Brooke Lernerⁿ , Daniel Nishijima^o, Charles Schleien^p, Stacy Shackelford^q, Erik Swartz^r, David W. Wright^s, Rachel Zhang^t, Andy Jagoda^d, and Bentley J. Bobrow^u

Recommendations

- A. Intravenous fluids should be administered in the prehospital setting to treat hypotension and/or limit hypotension to the shortest duration possible. (Strength of Recommendation: Strong)
- B. Hypotensive patients should be treated with isotonic fluids and/or blood products (if indicated and available) in the prehospital setting. (Strength of Recommendation: Strong)
- C. Hypertonic fluid resuscitation may be administered to patients with GCS scores <8 in whom increased ICP is suspected in the prehospital setting. (Strength of Recommendation: Weak)

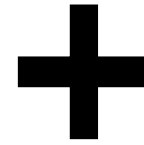


EARLY INTERVENTIONS: TRANSPORT

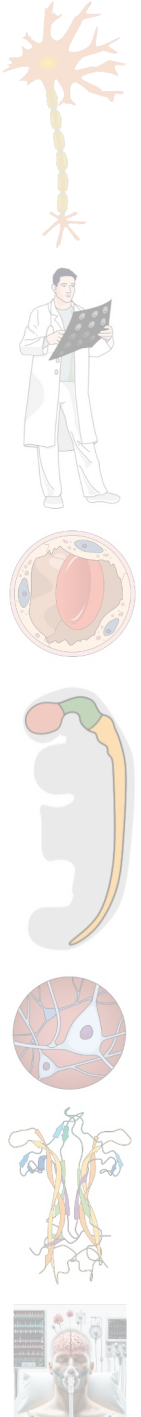
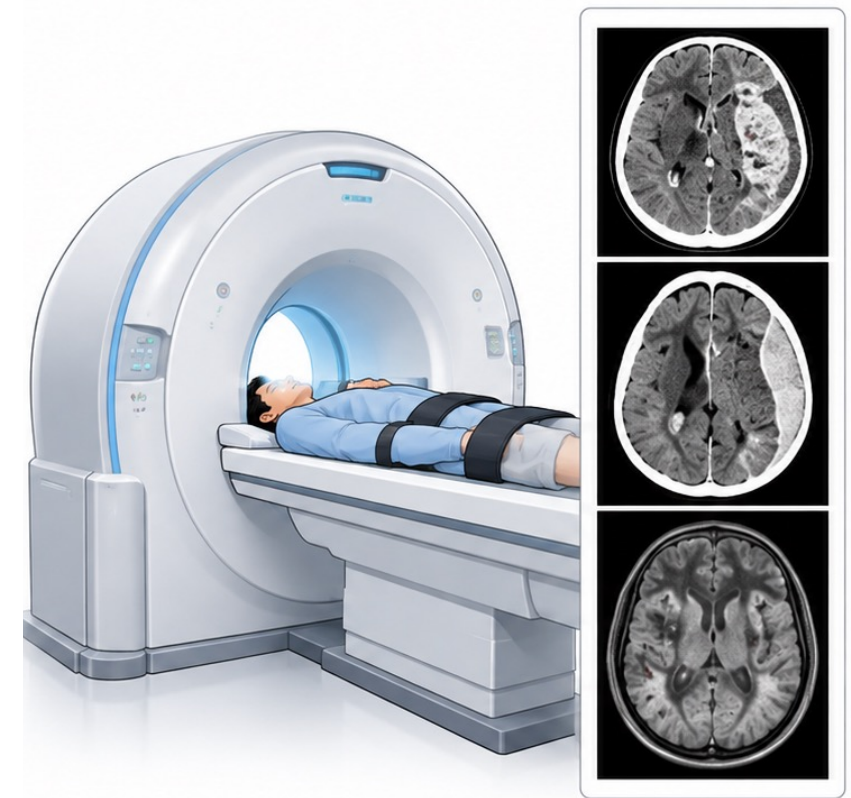
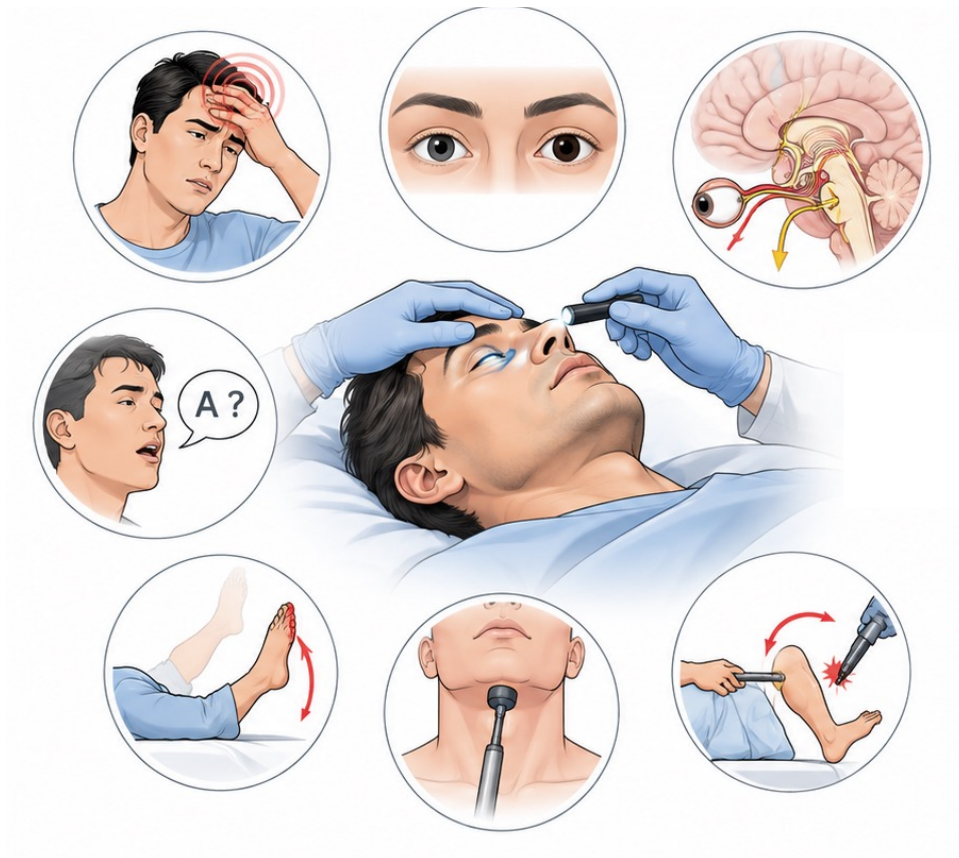


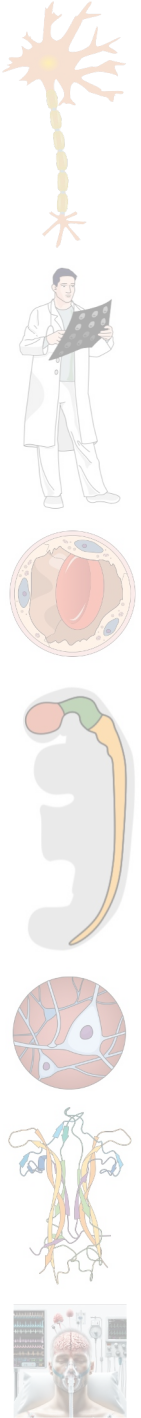
FIRST ASSESSMENT: ED ARRIVAL

CLINICAL EXAMINATION



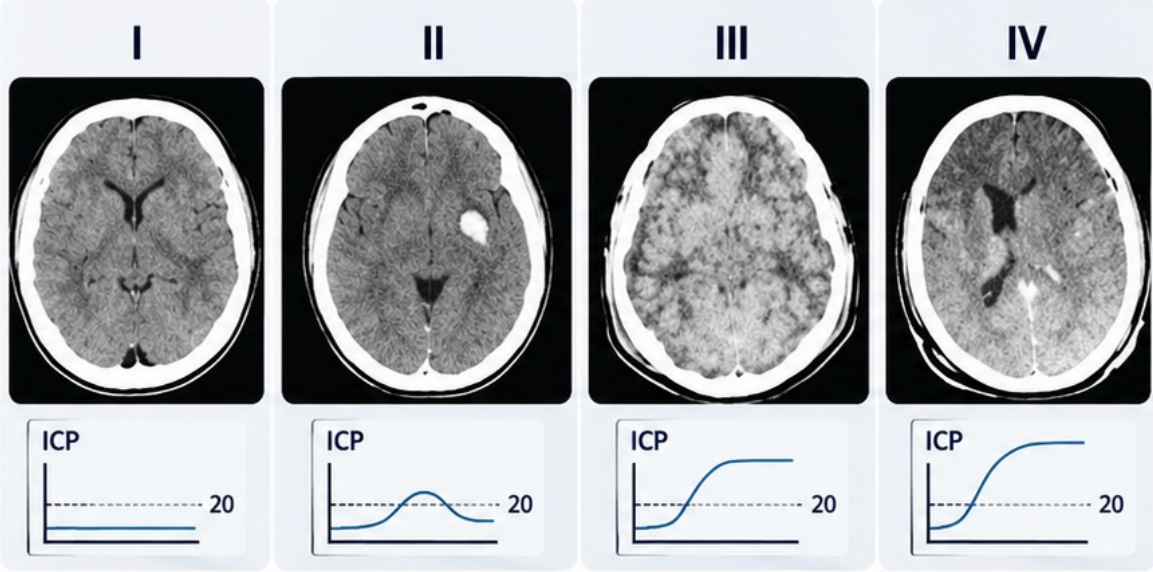
BRAIN IMAGING



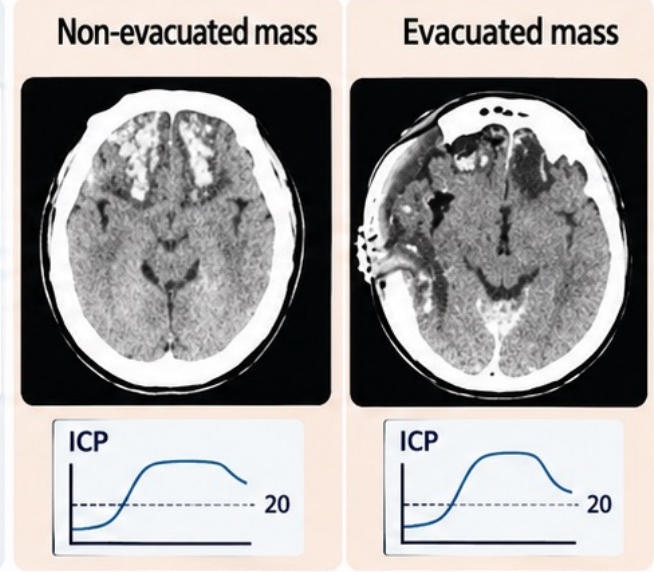


Lesion type
(TCDB, 1991)
n = 96

Evacuated mass lesions



Non-evacuated mass lesions



Incidence of ICH

0%

28.6%

63.2%

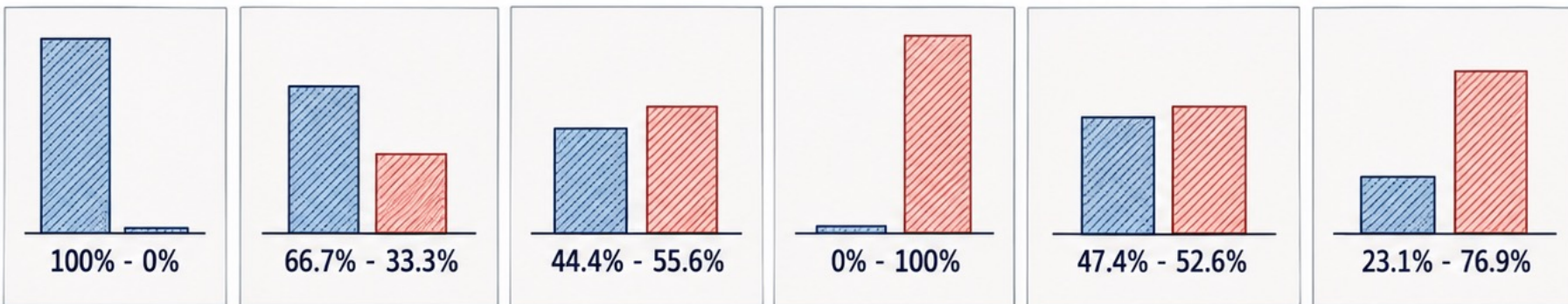
100%

65.2%

84.6%

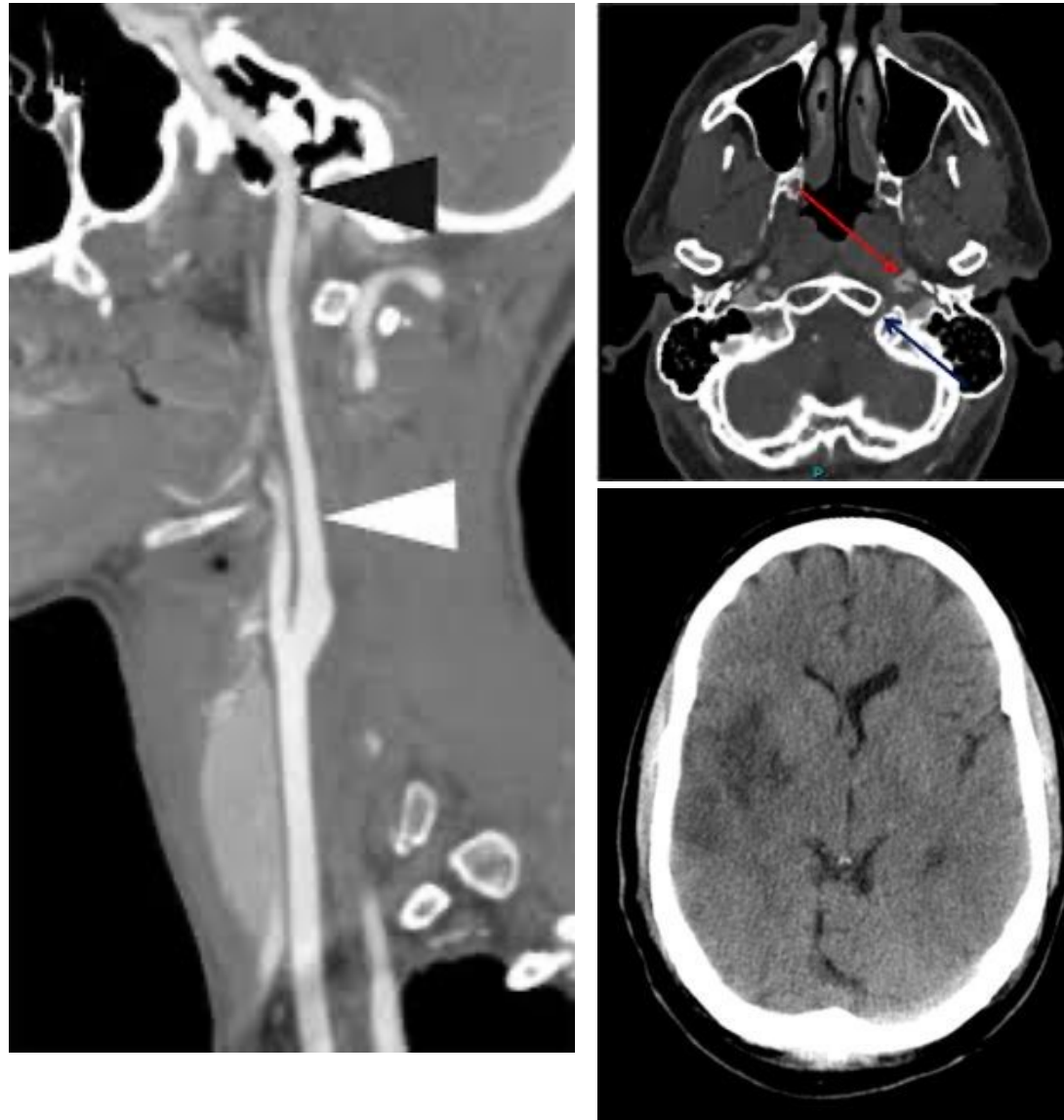
Results (GOSE)

 Good outcome (GO)
 Bad outcome (BO)





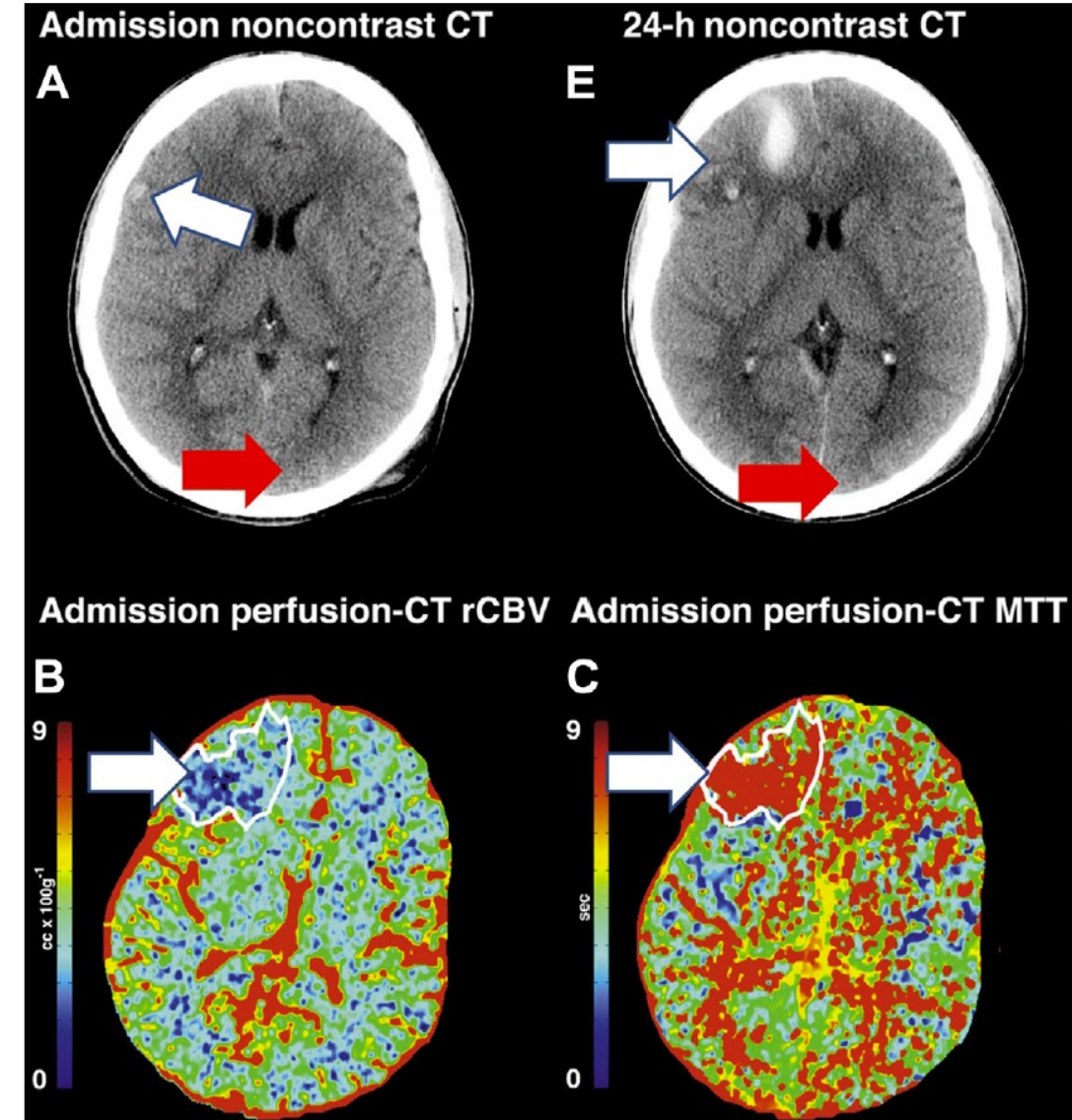
CT-ANGIO



Majidi, Neurocrit Care 2014

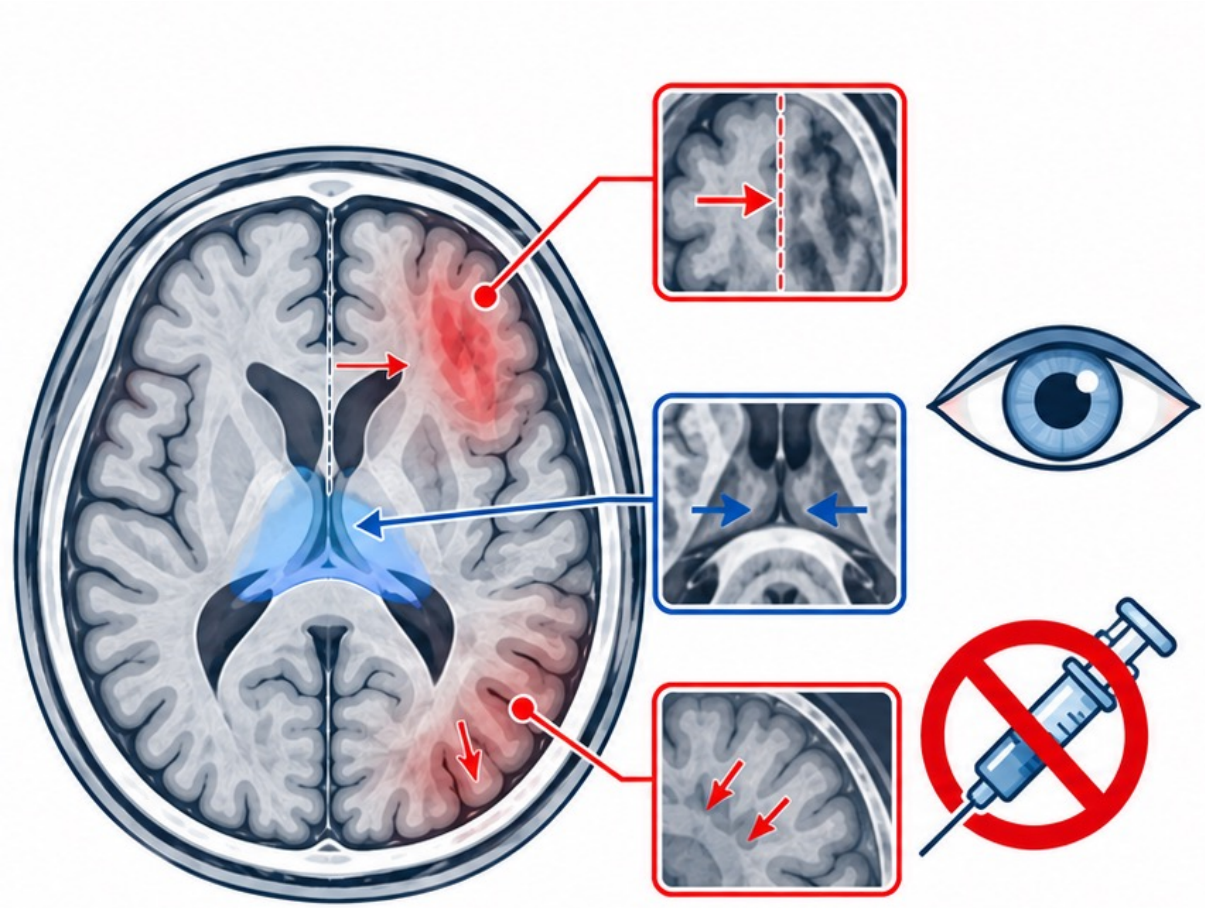
FS Taccone – HUB Brussels

CT-PERFUSION



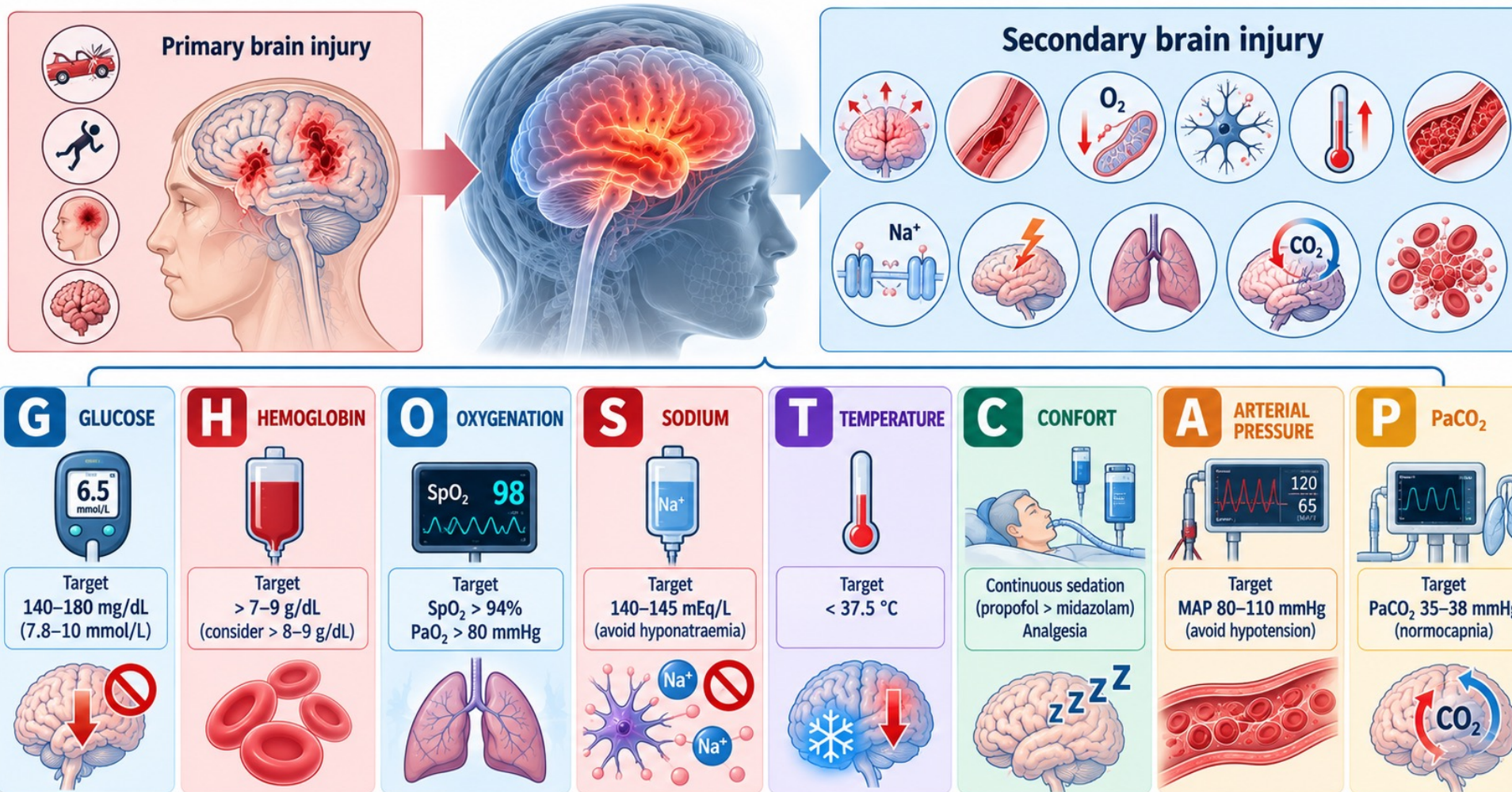
Douglas, Neuroimag Clin N Am 2017

FIRST ASSESSMENT: ED ARRIVAL

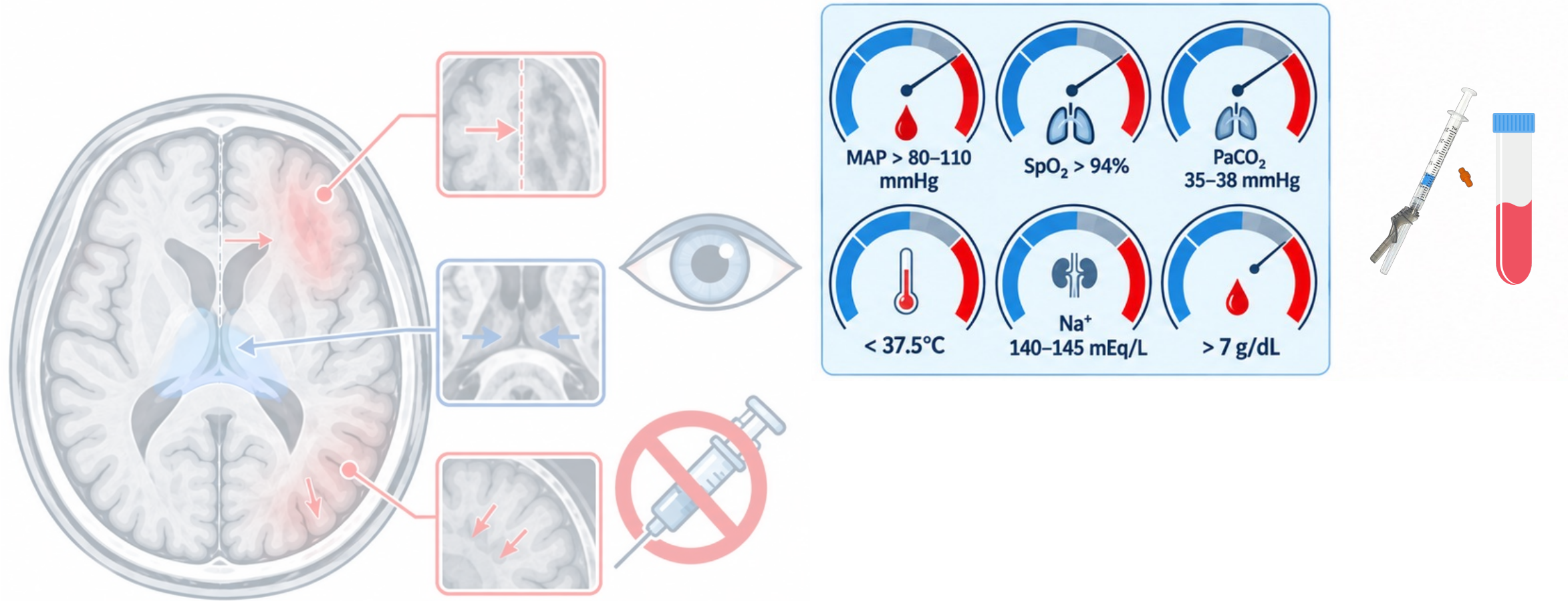


Picetti, World J Emerg Surg 2023

FIRST ASSESSMENT: ED ARRIVAL



FIRST ASSESSMENT: ED ARRIVAL



Picetti, World J Emerg Surg 2023



blood, saliva, CSF, urine

Astroglial cell
injury

Neuro

- Glial fibrillary acid protein (GFAP)
- Neuron-specific enolase (NSE)
- Ubiquitin carboxyl-terminal hydrolase L1 (UCH-L1)
- Neurofilament proteins (NF)
- Tau protein (tau)
- Myelin basic protein (MBP)

Interleukins (IL-6, IL-8, IL-10)

Factor

Extracellular
vesicles

(miRNA)

CBI-M TBI Characterization

Clinical (C)	Biomarker (B)	Imaging (I)	Modifier (M)
• Full GCS components (Eye-Verbal-Motor) • Quantitative pupillary reactivity • Post-traumatic amnesia duration	• Blood-based indicators of astroglial and neuronal tissue damage. • GFAP, UCH-L1, S100B • Objectively stratify injury severity.	• Pathoanatomical features identified on neuroimaging. • Moves beyond "abnormal CT" to specific lesion typing and volumetric quantification.	• Patient-specific variables influencing presentation and outcome. • Anticoagulant/antiplatelet use • Intoxication • Psychosocial barriers

NO EARLY PROGNOSTICATION !!!

Head injury prognosis

These prognostic models may be used as an aid to estimate mortality at 14 days and death and severe disability at six months in patients with traumatic brain injury (TBI). The predictions are based on the average outcome in adult patients with Glasgow coma score (GCS) of 14 or less, within 8 hours of injury, and can only support - not replace - clinical judgment. Although individual names of countries can be selected in the models, the estimates are based on two alternative sets of models (high income countries or low & middle income countries).

Country:

Age, years:

Glasgow coma score:

Pupils react to light:

Major extra-cranial injury? 

CT scan available? ☒

Presence of petechial haemorrhages:

Obiteration of the third ventricle or basal cisterns:

Subarachnoid bleeding:

Midline shift:

Non-evacuated haematoma:

Prediction

Risk of 14 day mortality (95% CI)	93.2% (89.5 - 95.7)
Risk of <u>unfavourable outcome</u> at 6 months	99.8% (99.6 - 99.9)

IMPACT

International Mission for Prognosis and Analysis of Clinical Trials in TBI

Search:

Home | TBI | IMPACT | Publications | References | Links | Contact

You are here: [TBI-IMPACT.org](#) » [IMPACT](#) » [Prognostic calculator](#)

IMPACT

Prognostic calculator

Based on extensive prognostic analysis the IMPACT investigators have developed prognostic models for predicting 6 month outcome in adult patients with moderate to severe head injury (Glasgow Coma Scale ≤ 12) on admission. By entering the characteristics into the calculator, the models will provide an estimate of the expected outcome at 6 months. We present three models of increasing complexity (Core, Core + CT, Core + CT + Lab). These models were developed and validated in collaboration with the CRASH trial collaborators on large numbers of individual patient data (the [IMPACT database](#)). The models discriminate well, and are particularly suited for purposes of classification and characterization of large cohorts of patients. Extreme caution is required when applying the estimated prognosis to individual patients.



List of subpages

- [Background](#)
- [Mission & Aims](#)
- [Collaboration](#)
- [Investigators](#)
- [Advisory Board](#)
- [IMPACT database](#)
- [Prognostic calculator](#)
- [IMPACT recommendations](#)
- [Common Data Elements \(Draft\)](#)
- [Data Sharing](#)
- [Acknowledgements](#)

IMPACT

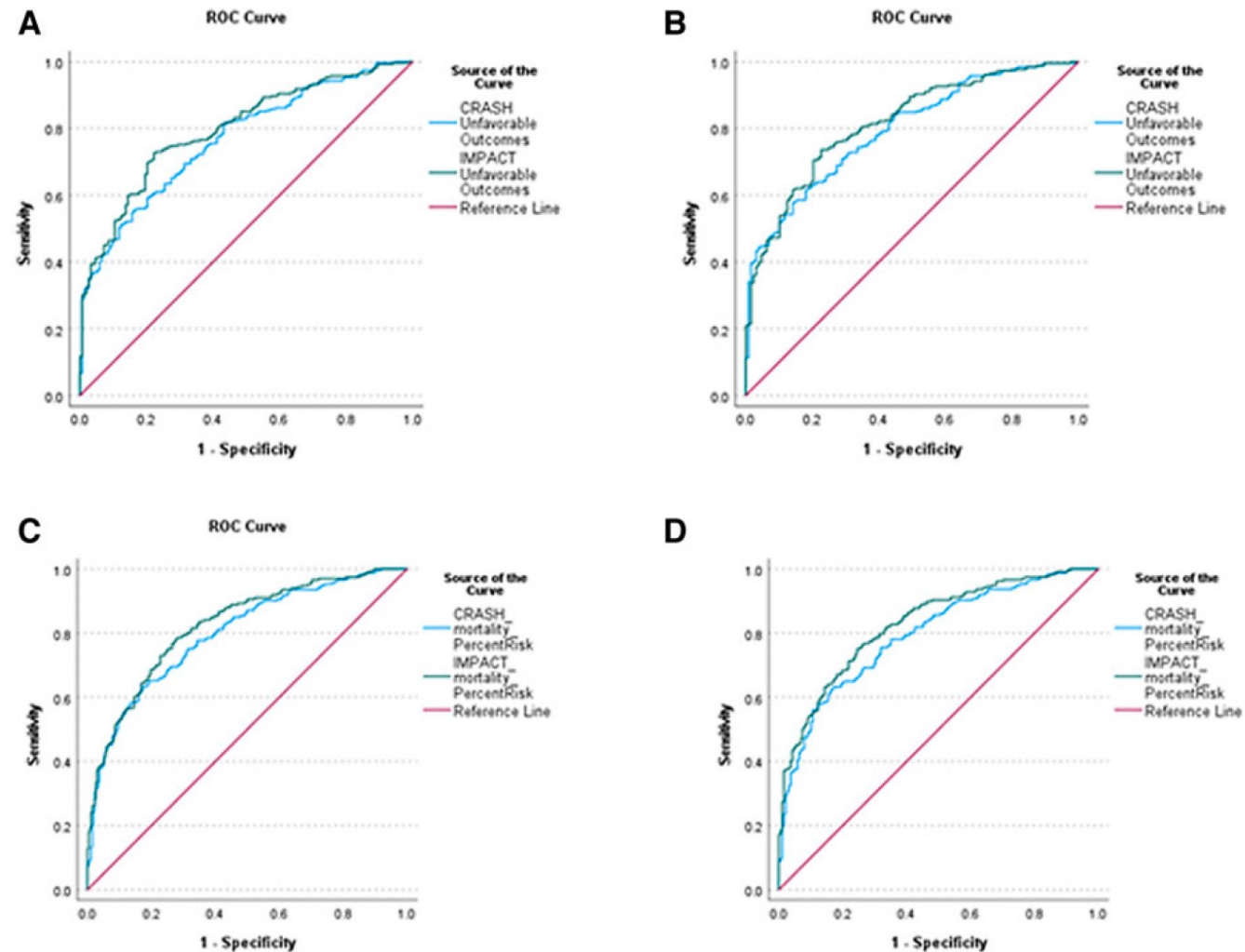
Prognostic models in TBI

1. Clinical Practice

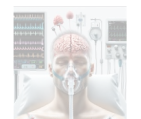
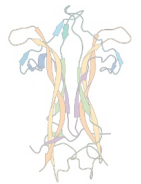
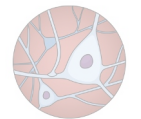
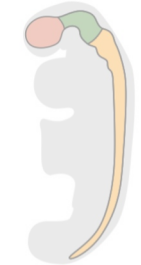
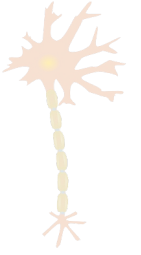
- [informing relatives](#)

Performance of CRASH and IMPACT Prognostic Models for Traumatic Brain Injury at 12 and 24 Months Post-Injury

Shawn R. Eagle,^{1,*} Enyinna Nwachuku,² Jonathan Elmer,³ Hansen Deng,¹ David O. Okonkwo,¹ and Matthew Pease⁴

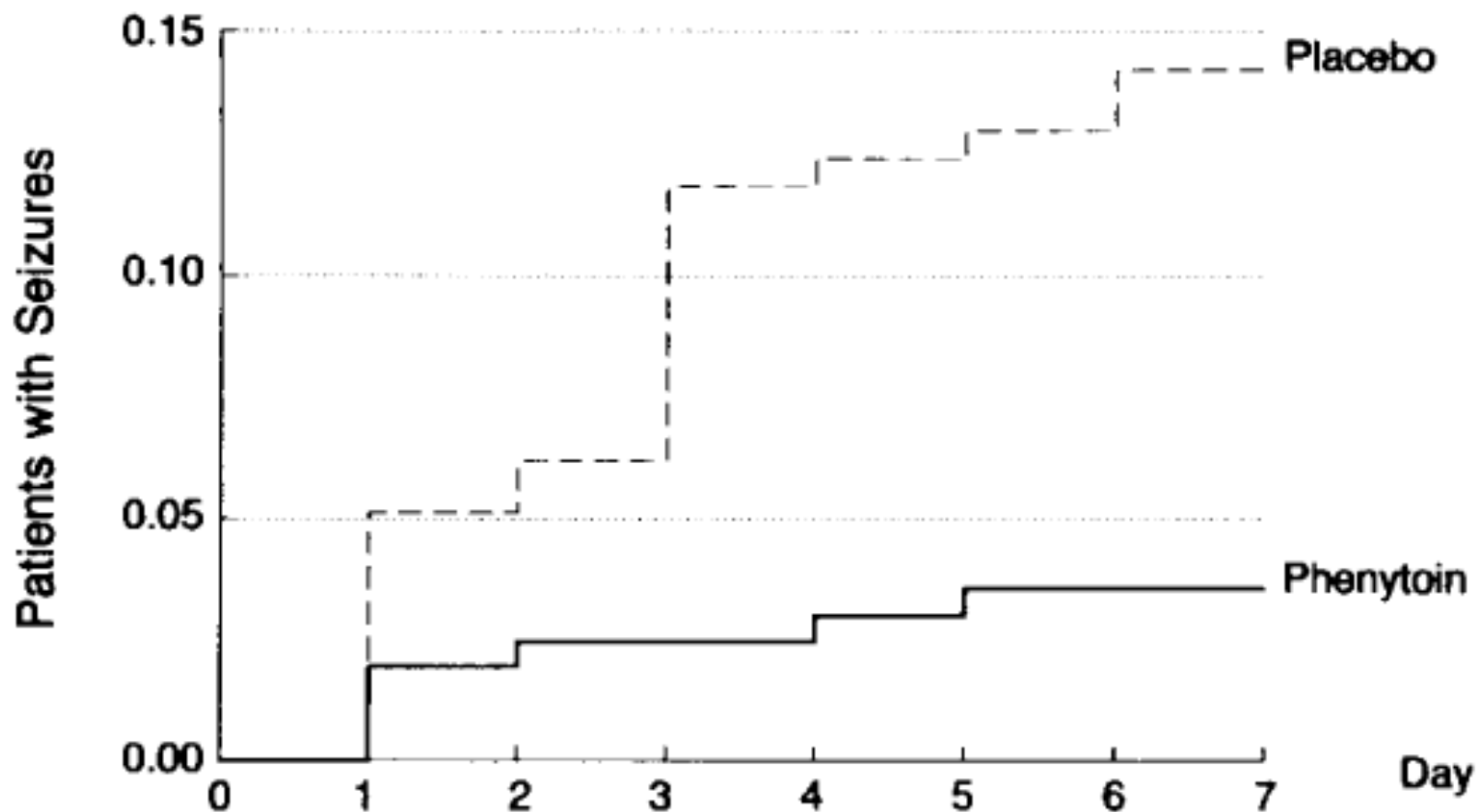


EARLY NEUROPROTECTION AFTER TBI ???



A RANDOMIZED, DOUBLE-BLIND STUDY OF PHENYTOIN FOR THE PREVENTION OF POST-TRAUMATIC SEIZURES

NANCY R. TEMKIN, PH.D., SUREYYA S. DIKMEN, PH.D., ALAN J. WILENSKY, M.D., PH.D.,
JANE KEIHM, R.N., M.S., SHARON CHABAL, R.N., M.S., AND H. RICHARD WINN, M.D.

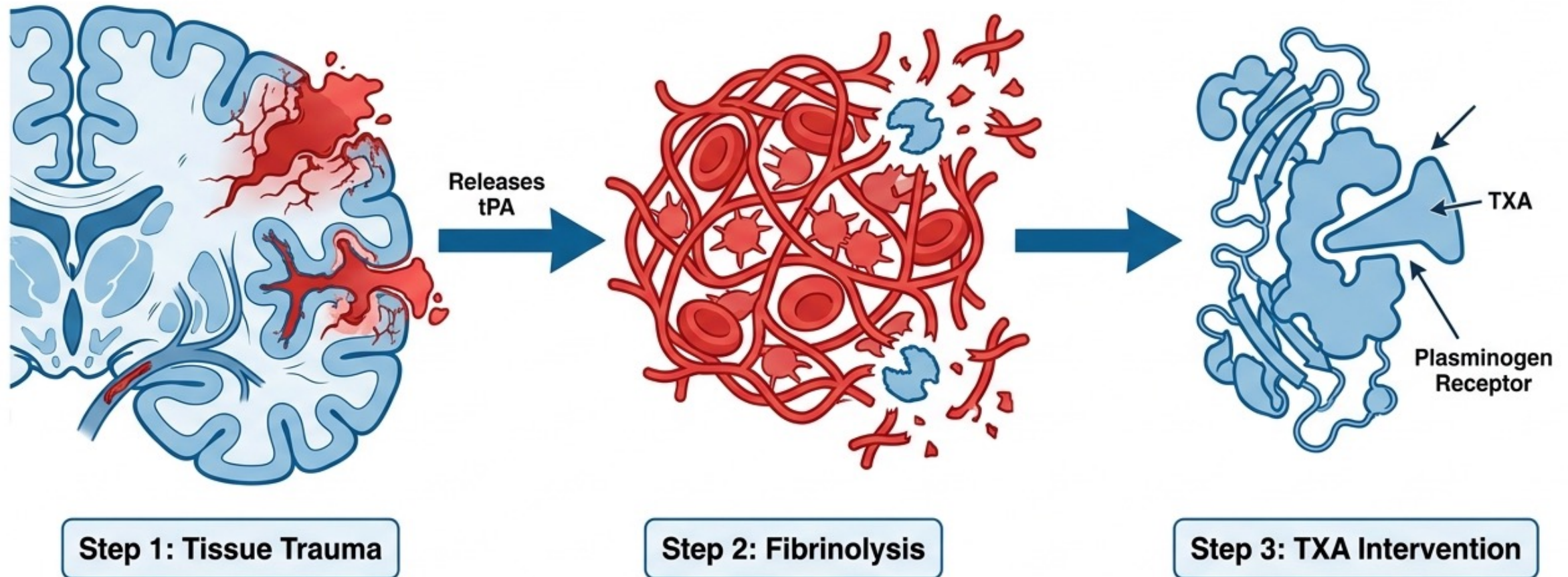


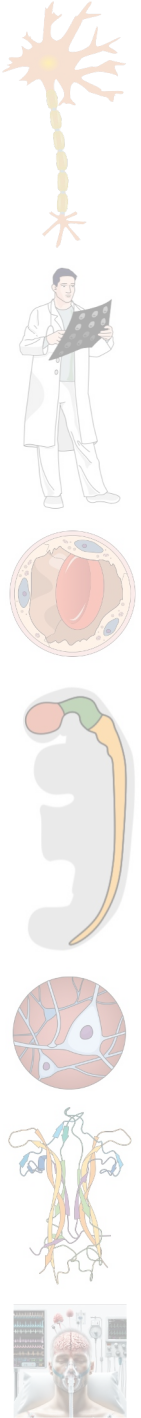
Cortical Contusion
Hemorrhagic Lesion
Depressed Skull Fracture
Penetrating Wound
Seizure <24 hrs
Adm GCS ≤ 10

Effects of tranexamic acid on death, disability, vascular occlusive events and other morbidities in patients with acute traumatic brain injury (CRASH-3): a randomised, placebo-controlled trial

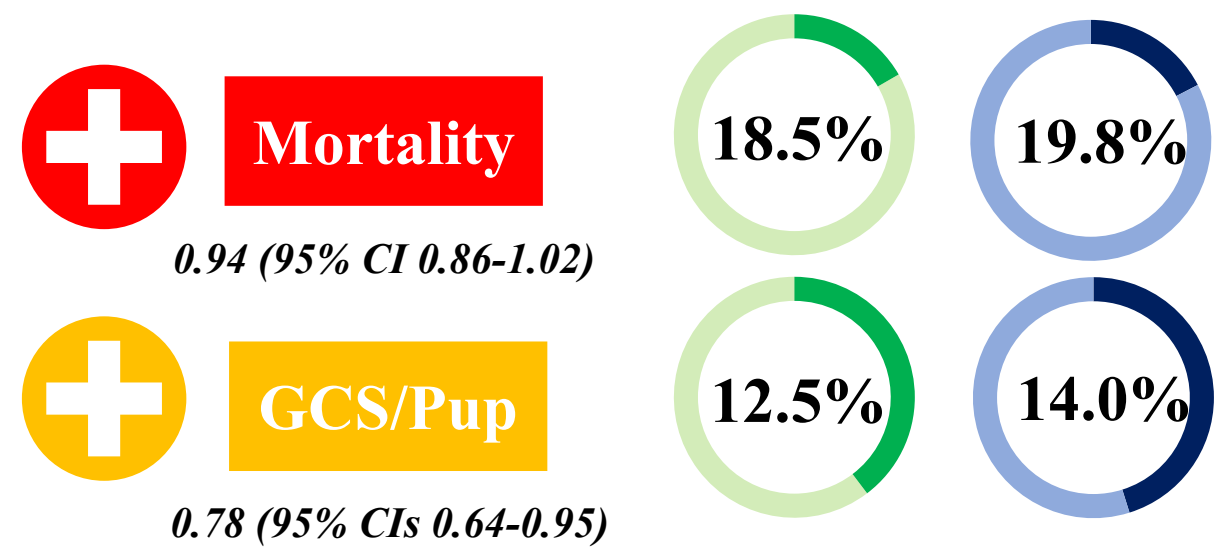
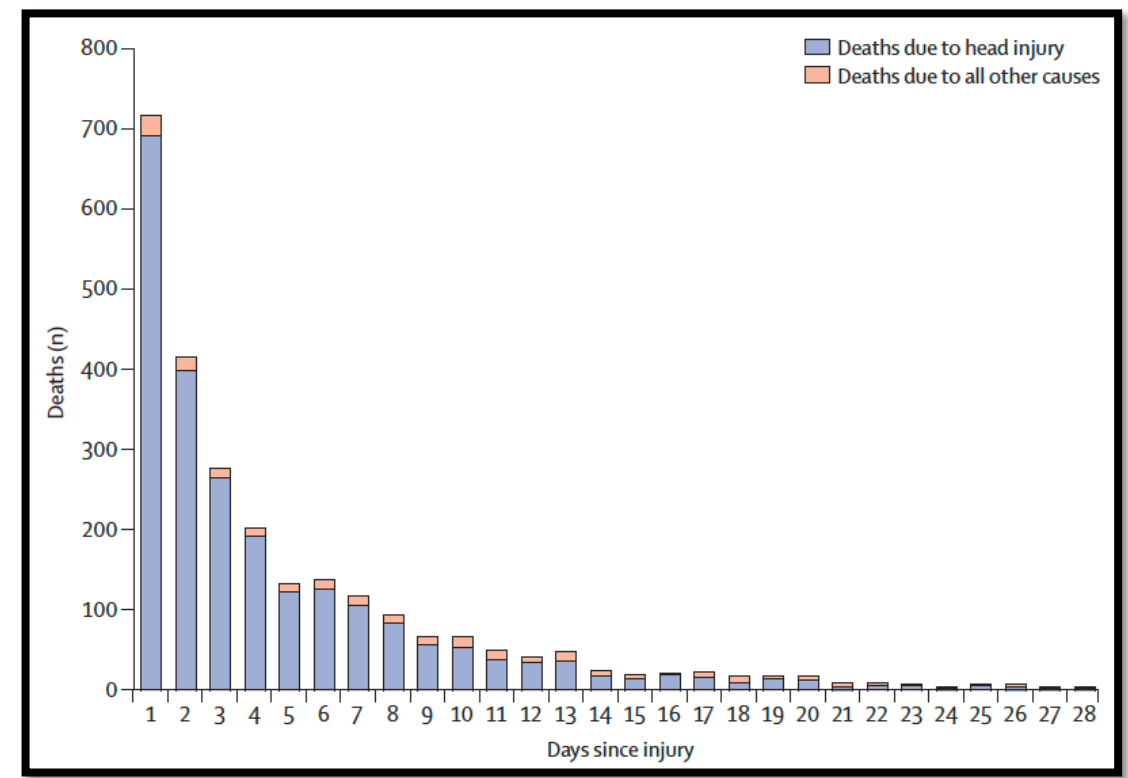
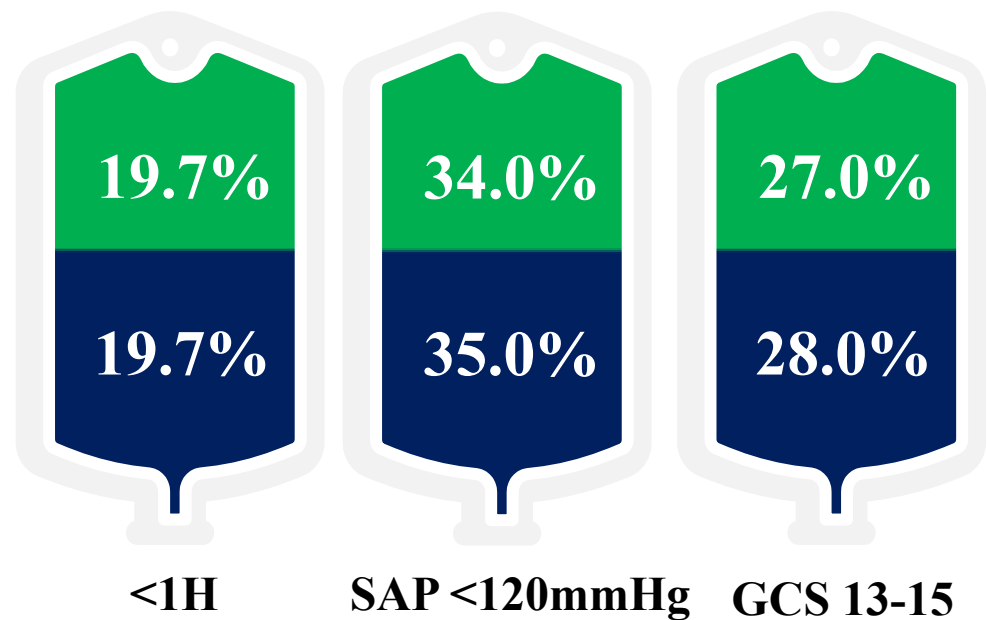
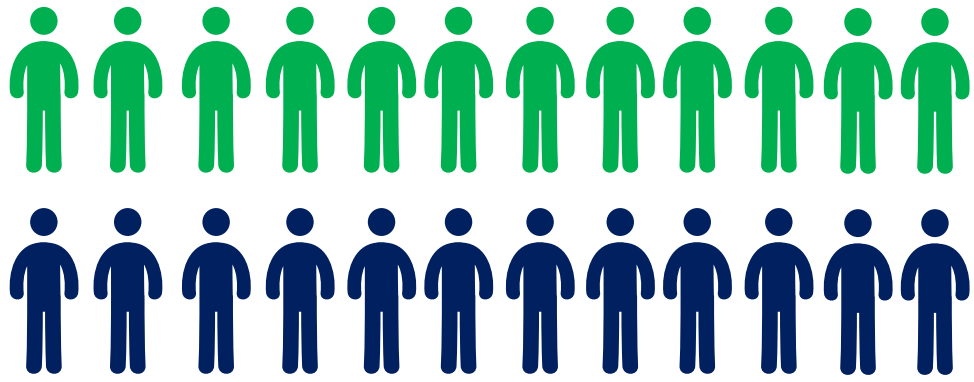
Published Online
October 14, 2019
[https://doi.org/10.1016/S0140-6736\(19\)32233-0](https://doi.org/10.1016/S0140-6736(19)32233-0)

*The CRASH-3 trial collaborators**



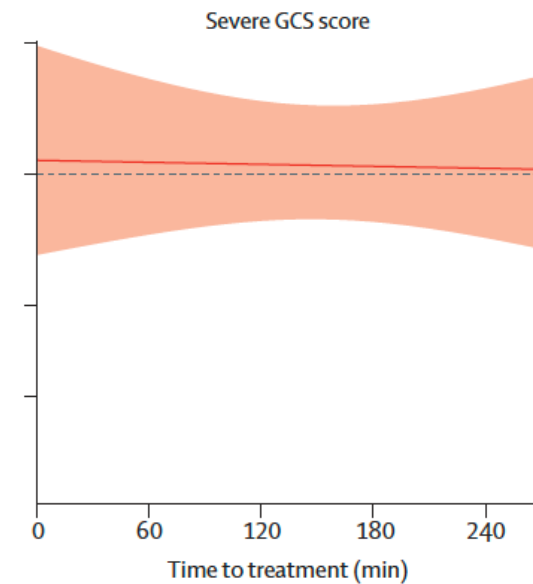
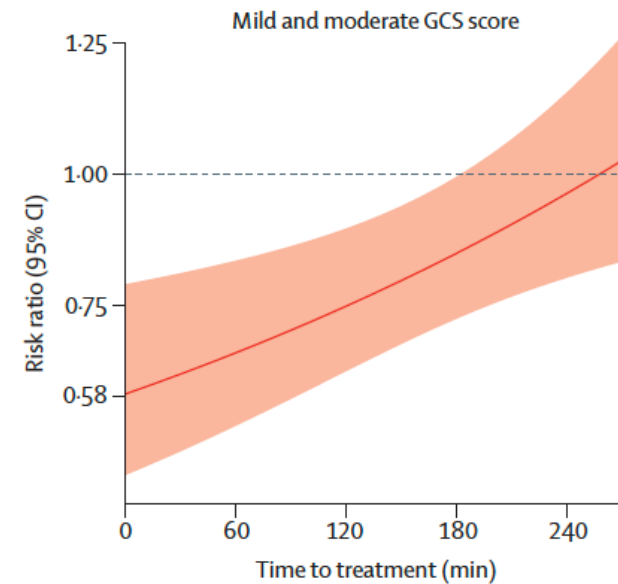
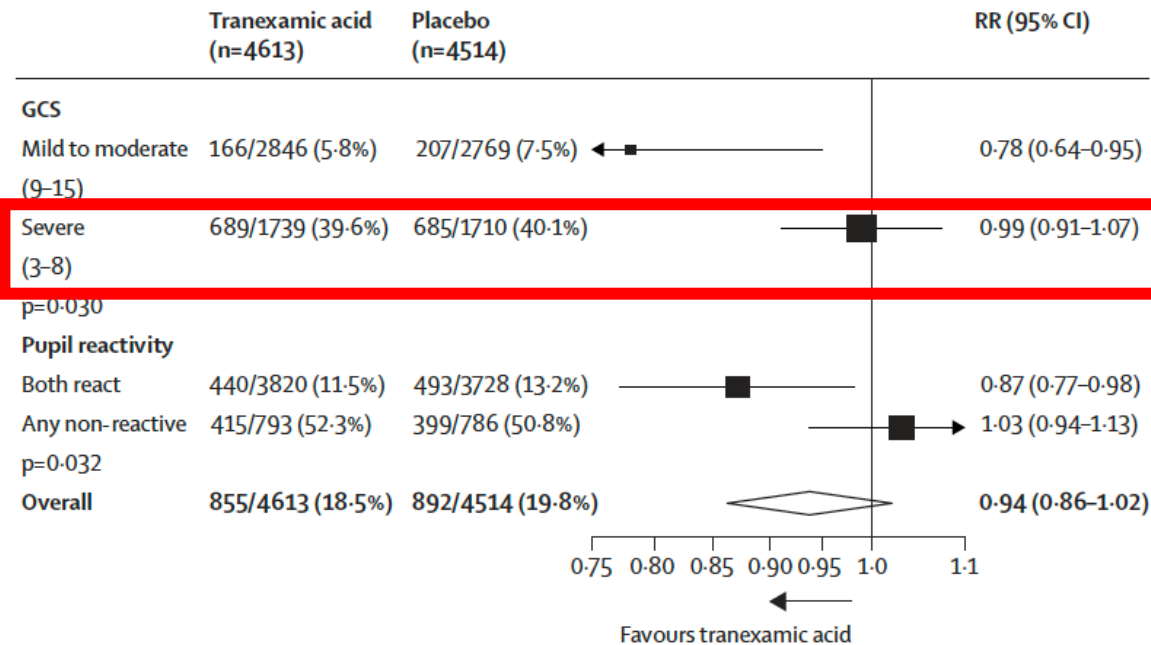


12737 → 9202 < 3h
7637 (GCS/Pupils)

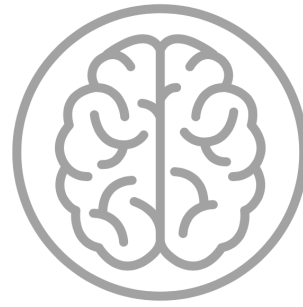


Effects of tranexamic acid on death, disability, vascular occlusive events and other morbidities in patients with acute traumatic brain injury (CRASH-3): a randomised, placebo-controlled trial

The CRASH-3 trial collaborators*



No differences in complications



GCS 3-8

NO TXA

> 3 hours

GCS 9-12

TIMING

< 3 hours

PUPILS

Reacting

TXA

GCS 13-15

?

ICH

CT-scan

No Bleeding

Not Reacting

NO TXA

Prehospital Guidelines for the Management of Traumatic Brain Injury – 3rd Edition

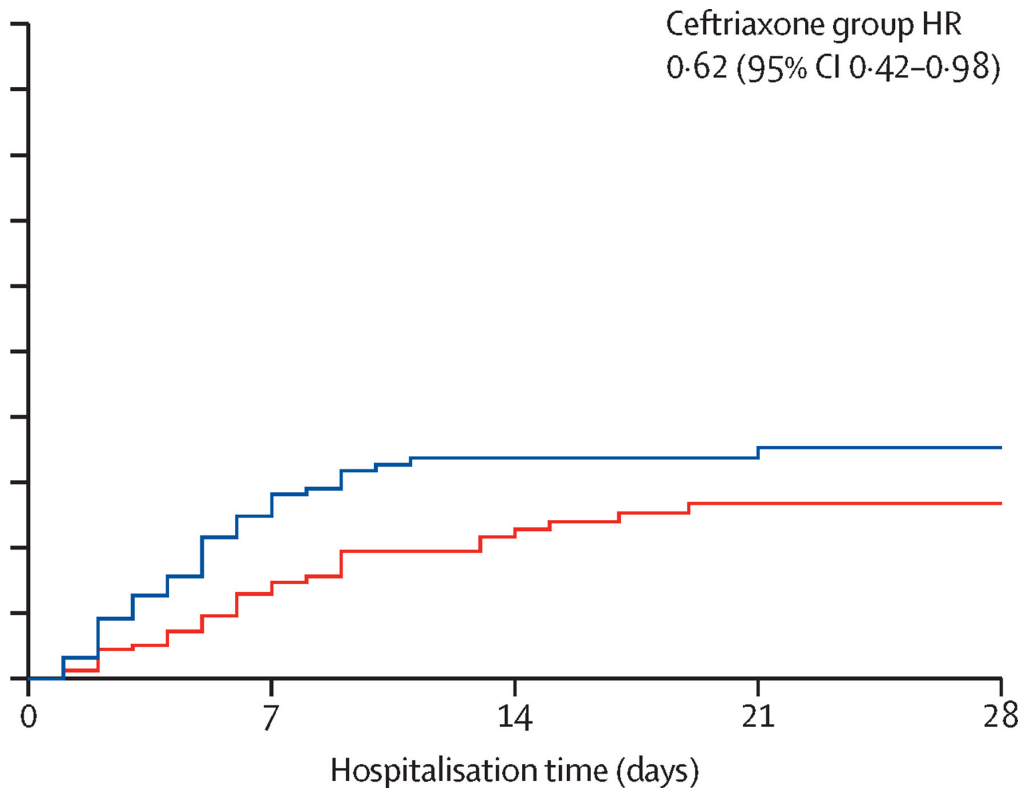
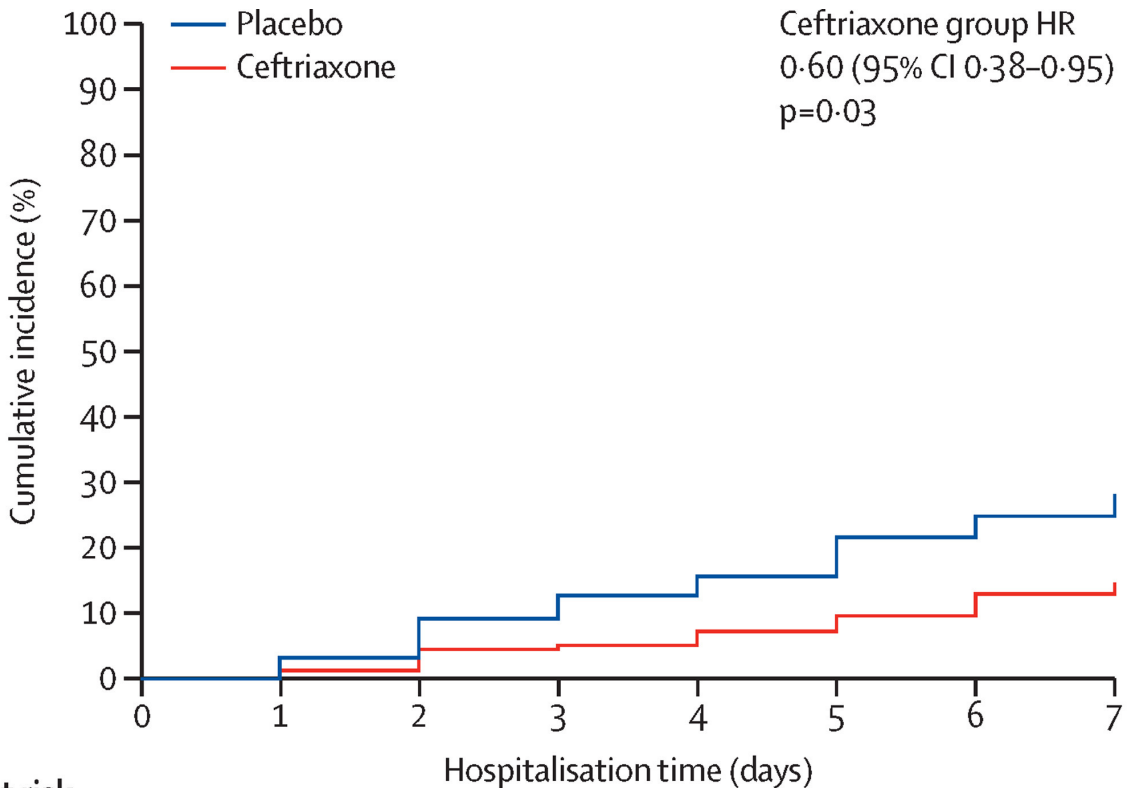
Al Lulla^a, Angela Lumba-Brown^b , Annette M. Totten^c, Patrick J. Maher^d, Neeraj Badjatia^e, Randy Bell^f, Christina T. J. Donayri^g, Mary E. Fallat^h, Gregory W. J. Hawrylukⁱ, Scott A. Goldberg^j, Halim M. A. Hennes^k, Steven P. Ignell^b, Jamshid Ghajar^l, Brian P. Krzyzaniak^m, E. Brooke Lernerⁿ , Daniel Nishijima^o, Charles Schleien^p, Stacy Shackelford^q, Erik Swartz^r, David W. Wright^s, Rachel Zhang^t, Andy Jagoda^d, and Bentley J. Bobrow^u

- E. Prehospital administration of TXA therapy is not generally and widely indicated for the prophylactic treatment of suspected ICH or elevated ICP. However, decisions by health care systems may vary and further evidence may support more general use. (Strength of Recommendation: Strong)



Ceftriaxone to prevent early ventilator-associated pneumonia in patients with acute brain injury: a multicentre, randomised, double-blind, placebo-controlled, assessor-masked superiority trial

Claire Dahyot-Fizelier, Sigismond Lasocki, Thomas Kerforne, Pierre-Francois Perrigault, Thomas Geeraerts, Karim Asehnoune, Raphaël Cinotti, Yoann Launey, Vincent Cottenceau, Marc Laffon, Thomas Gaillard, Matthieu Boisson, Camille Aleyrat, Denis Frasca, Olivier Mimos, on behalf of the PROPHY-VAP Study Group and the ATLANREA Study Group*

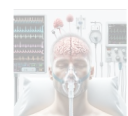
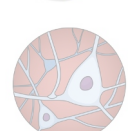
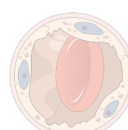
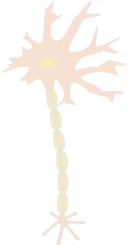


Number at risk

Ceftriaxone	162	160	149	134	125	119	107	100
Placebo	157	154	140	121	109	98	93	86

162	100	65	46	20
157	86	58	37	27

SHOULD I ASK FOR AN ICP ?



1

THE STANDARD

Severe TBI (GCS 3–8 after resuscitation)
AND
Abnormal Admission CT (hematomas, contusions, swelling, compressed basal cisterns).

2

NORMAL CT, HIGH RISK

Severe TBI with Normal CT + ≥ 2 of the following Risk Factors:

- Age > 40
- Unilateral/Bilateral motor posturing
- SBP < 90 mmHg

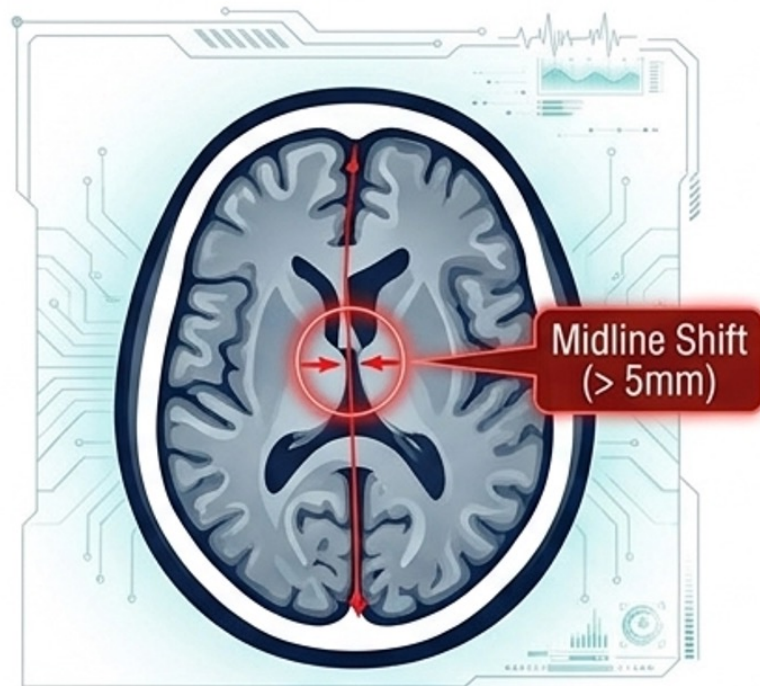
3

POST-OPERATIVE

Post-evacuation of intracranial mass lesions
IF:

- Preoperative GCS motor ≤ 5
- Anisocoria or bilateral mydriasis

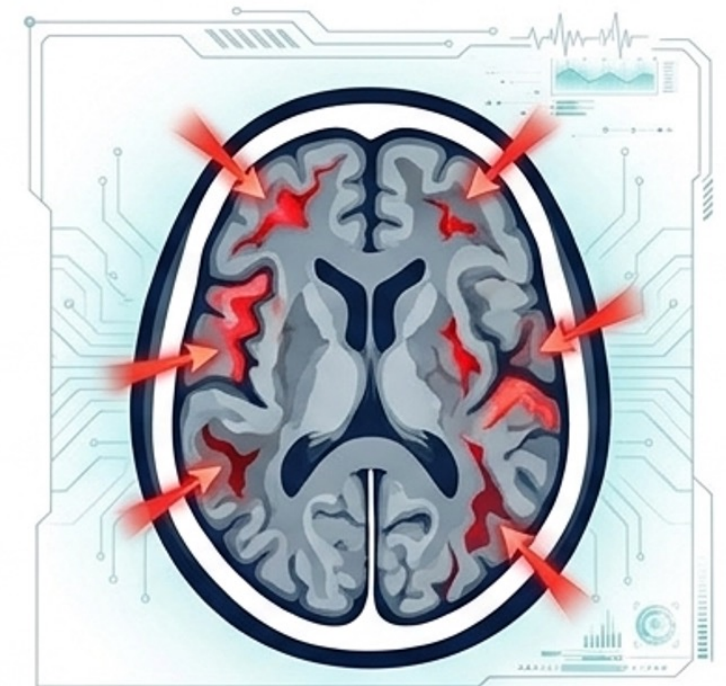
SHOULD I ASK FOR AN ICP ?



Midline Shift (> 5mm)



Compression or complete obliteration of basal cisterns



Multiple/large intraparenchymal contusions
(high risk for expansion/blossoming at 48-72h)

Geeraerts, ACCP 2018

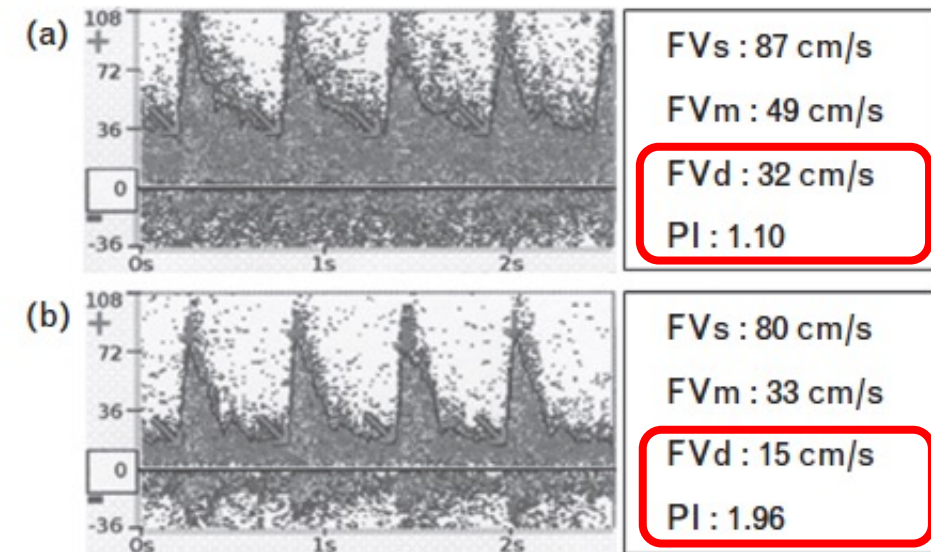
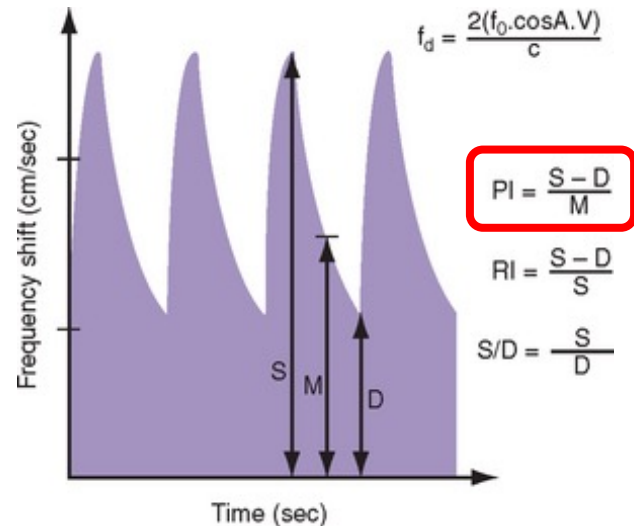
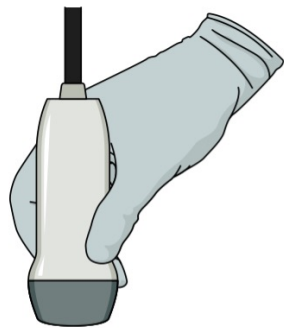
- ✓ Reduced **FVd** (<20 cm/sec) and Increased **PI** (>1.2) predict secondary neuro-worsening and the need for subsequent therapies to reduce elevated ICP
- ✓ Estimation of **non-invasive ICP** (high NPV)

Bouzat, Neurosurgery 2011

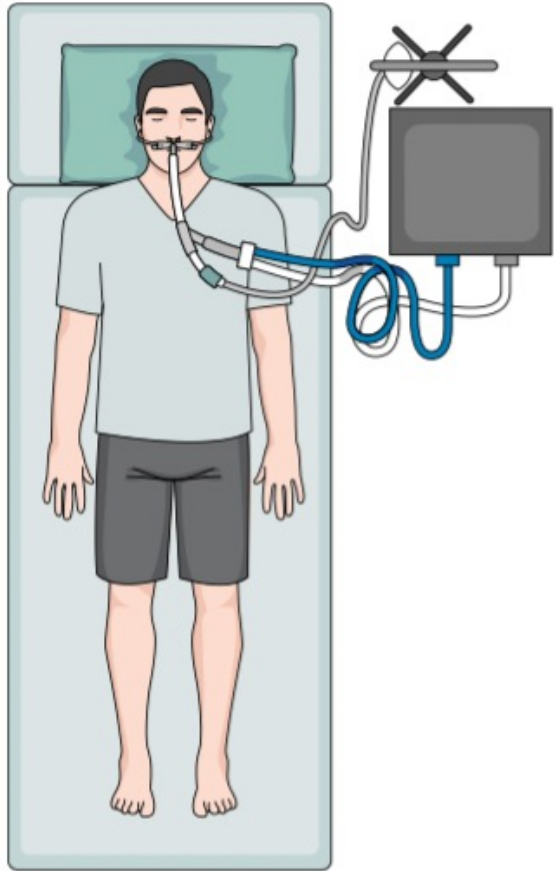
Ract, ICM 2007

Rasulo, Crit Care 2022

« **AWAKE** »



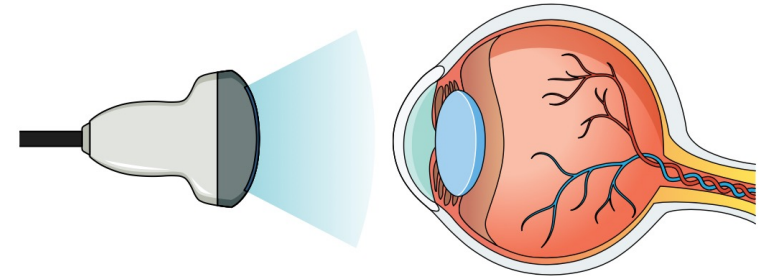
CAN I PREDICT ELEVATED ICP ?



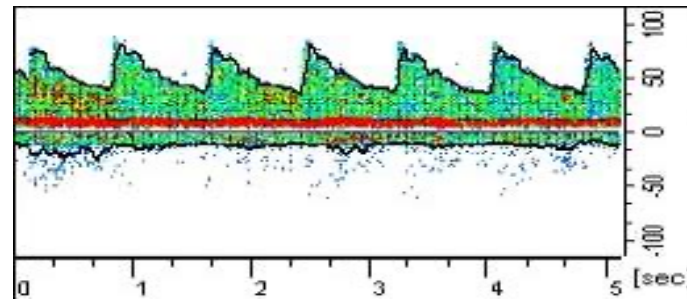
UNCONSCIOUS



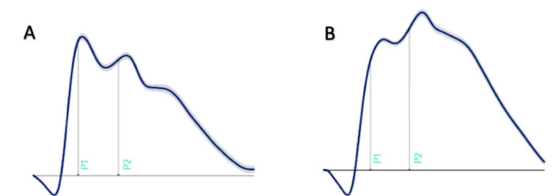
$NPI < 3$



$ONSD > 5.5-6.0 \text{ mm}$



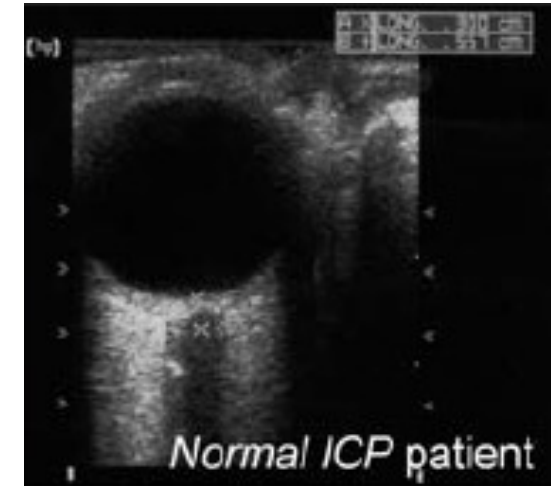
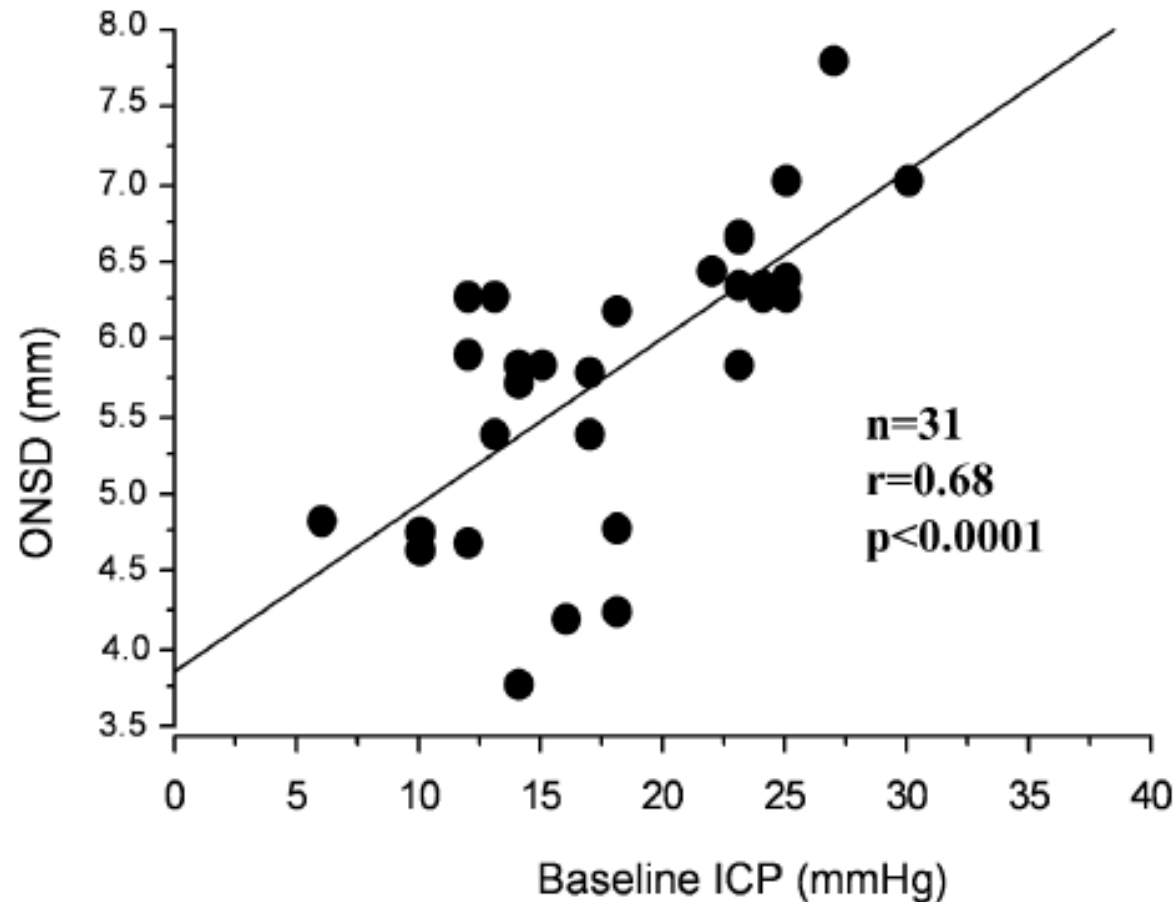
**$Vd < 20 \text{ cm/sec}$ or
 $PI > 1.2$**



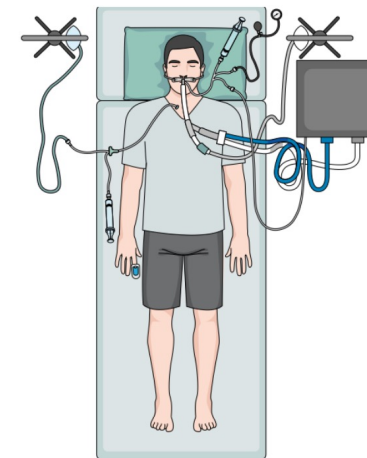
$P2 > P1$

Ultrasonography of the optic nerve sheath may be useful for detecting raised intracranial pressure after severe brain injury

Thomas Geeraerts
Yoann Launey
Laurent Martin
Julien Pottecher
Bernard Vigué
Jacques Duranteau
Dan Benhamou

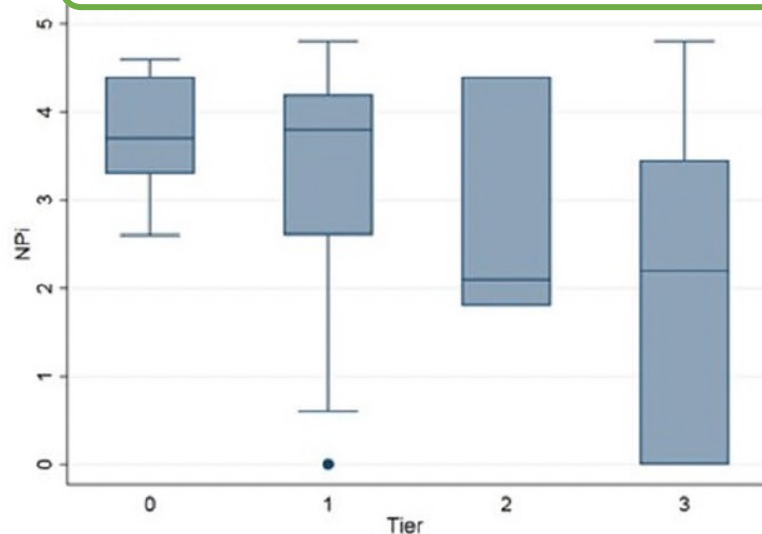


Prediction of neurocritical care intensity through automated infrared pupillometry and transcranial doppler in blunt traumatic brain injury: the NOPE study

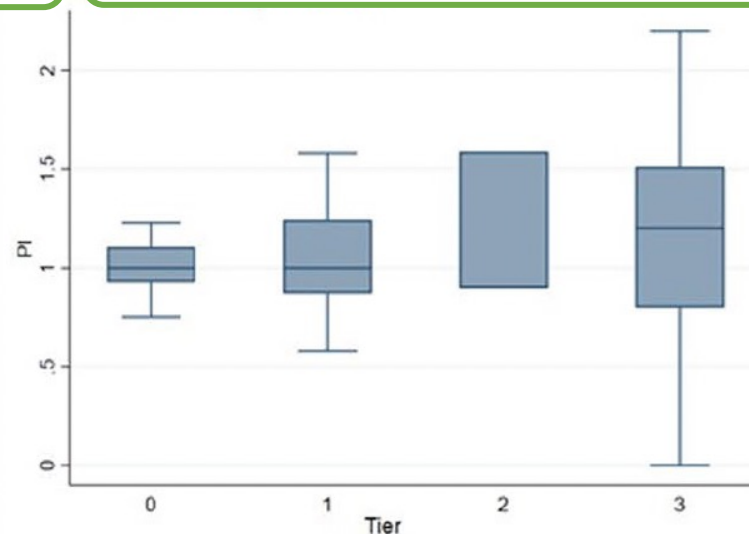


Pierluigi Banco¹ · Fabio Silvio Taccone² · Dimitri Sourd³ · Claudio Privitera⁴ · Jean-Luc Bosson³ · Thomas Luz Teixeira² · Anais Adolle¹ · Jean-François Payen¹ · Pierre Bouzat¹ · Tobias Gauss¹

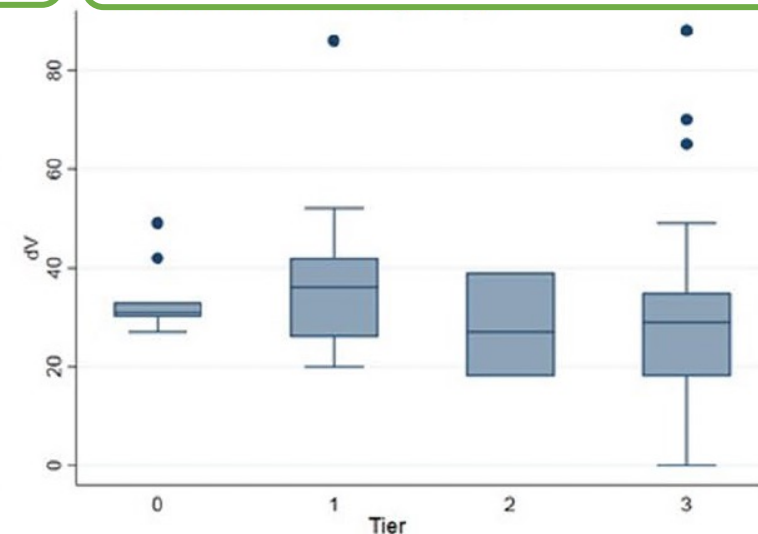
Pupillometry, NPi



TCD, PI



TCD, FVd



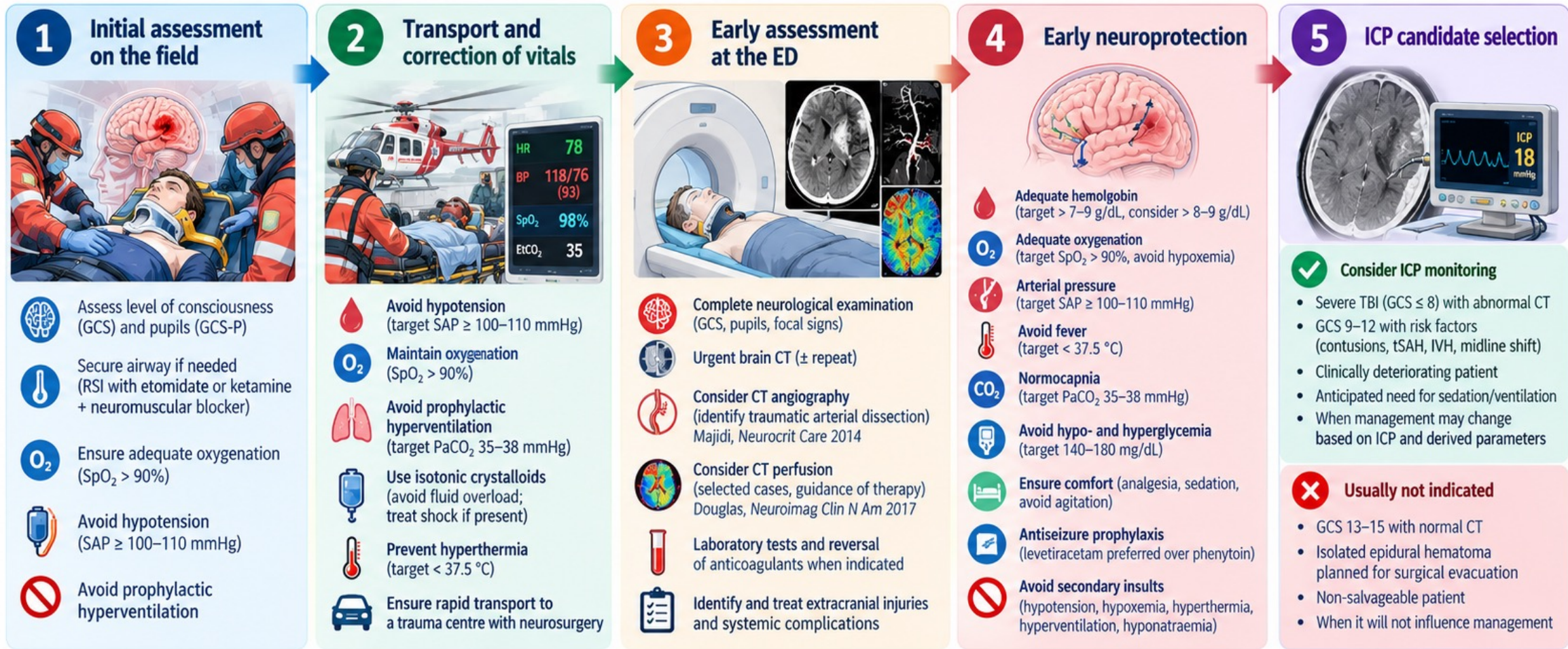
HOW TO SELECT CANDIDATES FOR ICP ?

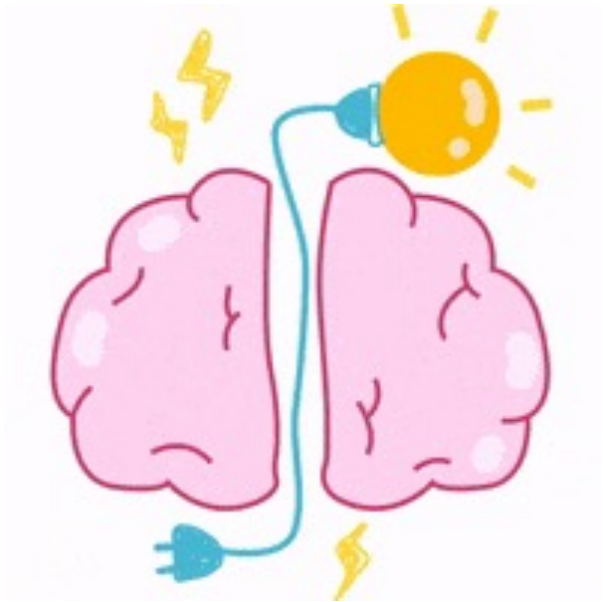
CONFERENCE REPORTS AND EXPERT PANEL

The Brussels consensus for non-invasive ICP monitoring when invasive systems are not available in the care of TBI patients (the B-ICONIC consensus, recommendations, and management algorithm)



CONCLUSIONS





Thanks

