Current and Future Trends of Neurotrauma Management in a Global Context

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Medical and Research Director, Fundación Meditech, Cali (COL)

Administrative Committee Publications Editor, FLANC
Chair, International Committee, Neurotrauma and Critical Care Join Section, AANS/CNS
Co-Chair, Neurotraumatology Committee, WFNS

Board President, Global Neuro Foundation (SWI)
International Advisor, Brain Trauma Foundation (USA)

There is No Conflict of Interest

Global Health Research Group on Neurotrauma

UNIVERSITY OF CAMBRIDGE

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NIHR Global Health Research Group on Acquired Brain and Spine Injuries

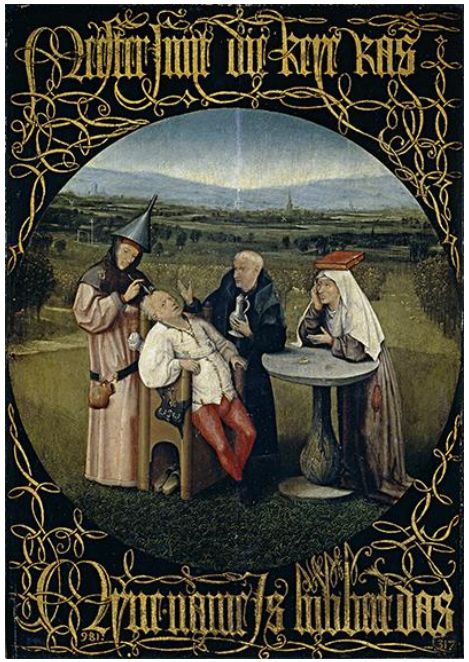
Objectives of the Lecture

- Discuss fundamental aspects of neurotrauma within the framework of the global impact and the pathophysiological aspects.

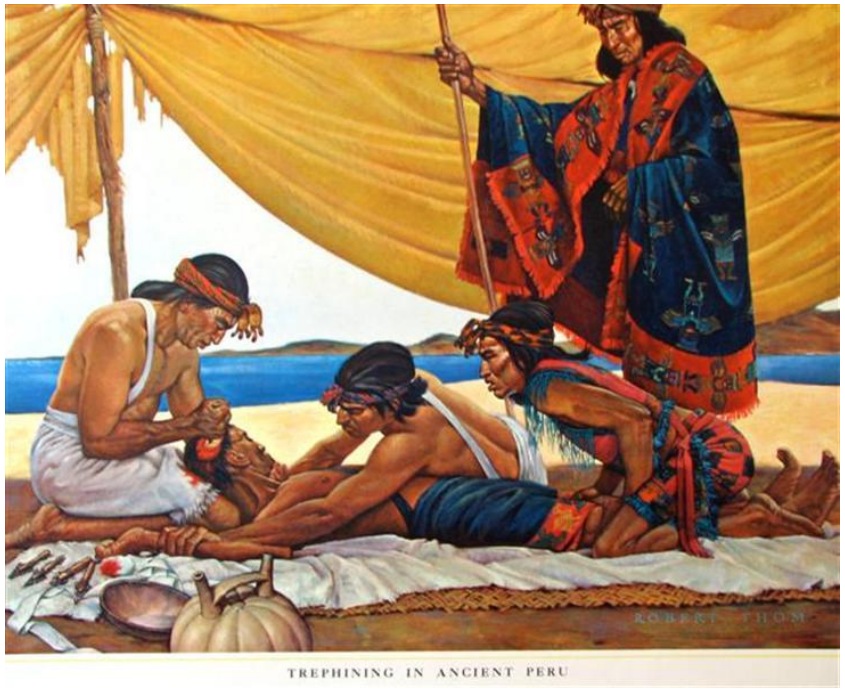
- Discuss present trends in the process of diagnosis and decision-making for the comprehensive management of TBI based on scientific evidence and expert consensus.

- Share transitions from present to future trends in personalized and precision approaches that will impact the outcome of TBI patients within an organized care system.

1st Section: Objective 1



Extracting the Stone of Madness
El Bosco (1475), Museo del Prado, Spain



Trephining in Ancient Peru
Robert Thom (1970), Trowbridge Gallery, Australia

"Discuss fundamental aspects of neurotrauma within the framework of the global impact and the pathophysiological aspects"

Impact and Global Burden of the Disease

JNS

CLINICAL ARTICLE

Estimating the global incidence of traumatic brain injury

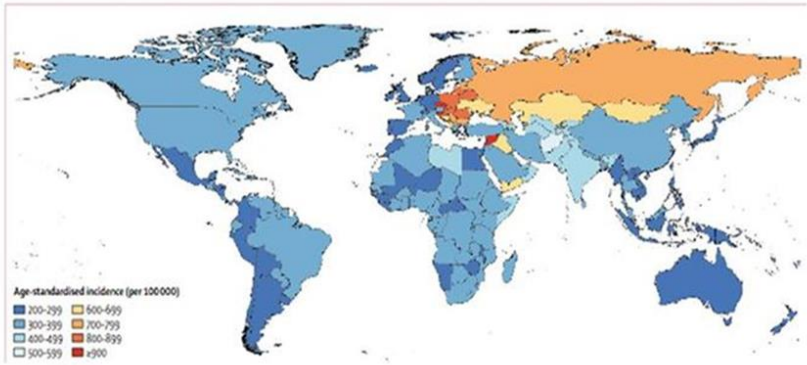
Michael C. Dewan, MD, MSCI,[1,2] Abbas Rattani, MBe,[1,3] Saksham Gupta, BA,[4] Ronnie E. Baticulon, MD,[5] Ya-Ching Hung, MD, MPH,[1] Maria Punchak, MSc,[1,6] Amit Agrawal, MCh,[7] Amos O. Adeleye, MBBS,[8,9] Mark G. Shrime, MD, MPH, PhD,[1,10] Andrés M. Rubiano, MD,[11] Jeffrey V. Rosenfeld, MD, MS,[12–14] and Kee B. Park, MD[1]

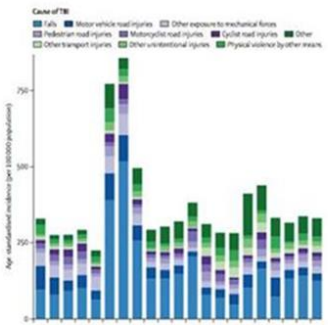
J Neurosurg April 27, 201

Global, regional, and national burden of traumatic brain injury and spinal cord injury, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016

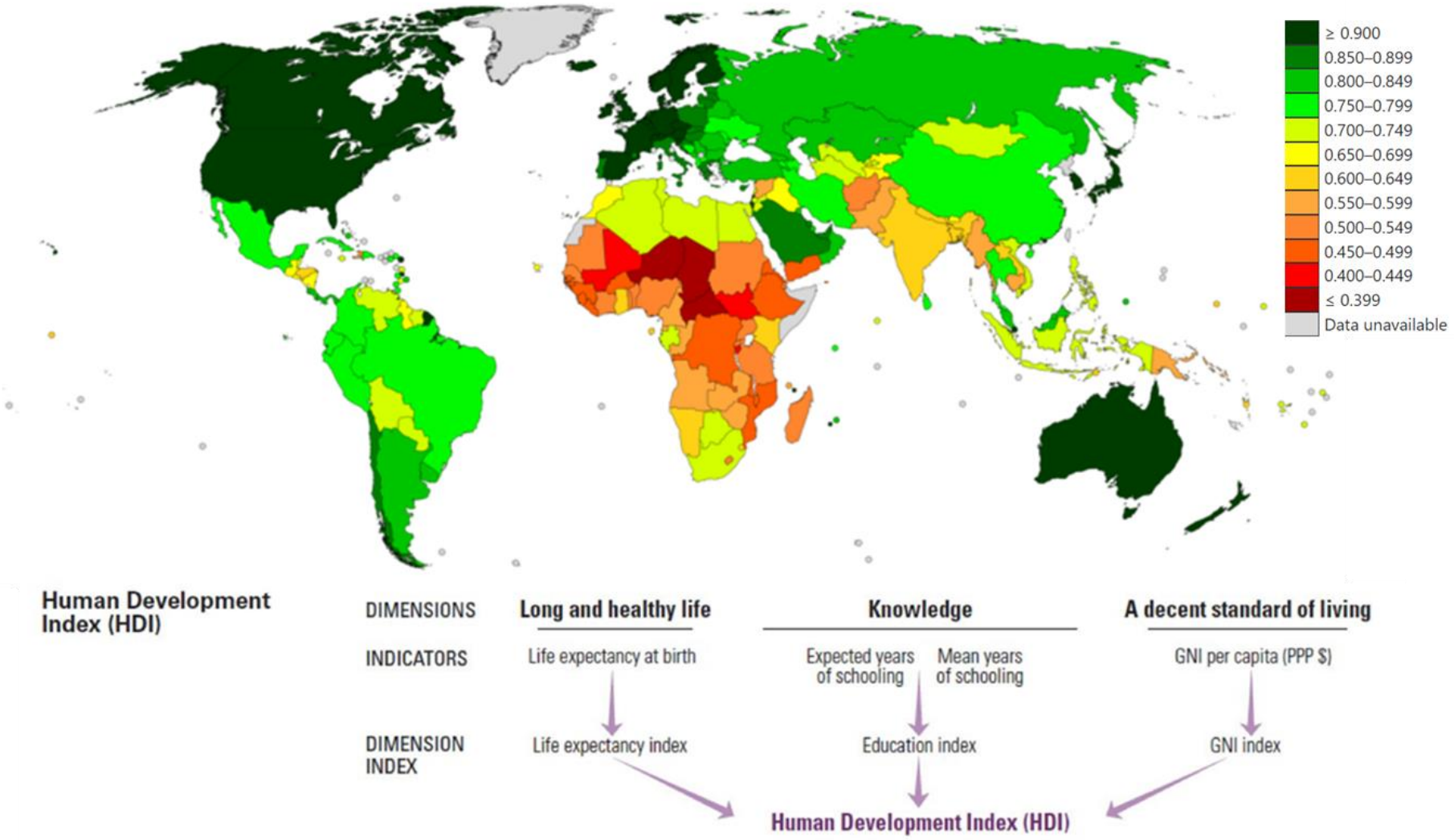
GBD 2016 Traumatic Brain Injury and Spinal Cord Injury Collaborators*

Lancet Neurol 2019; 18: 56–87

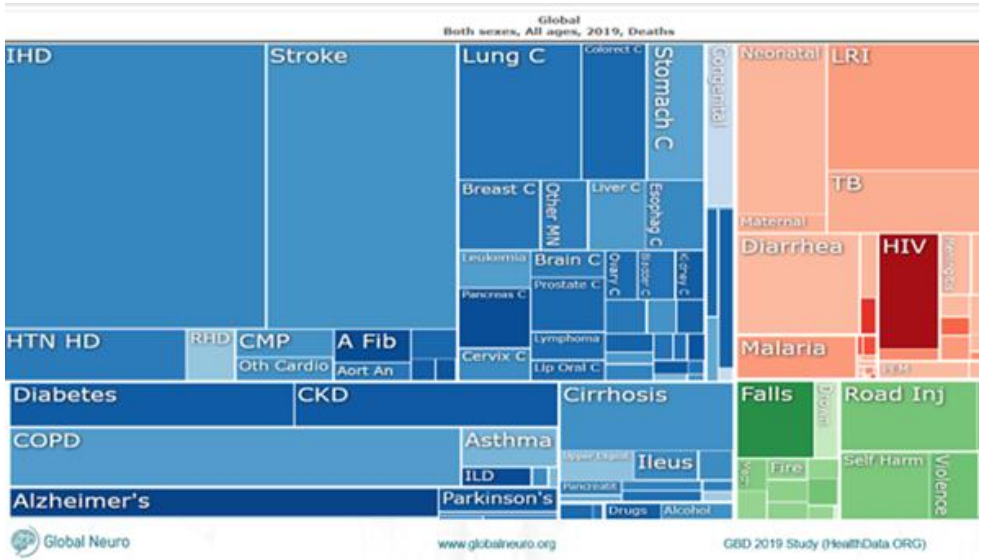


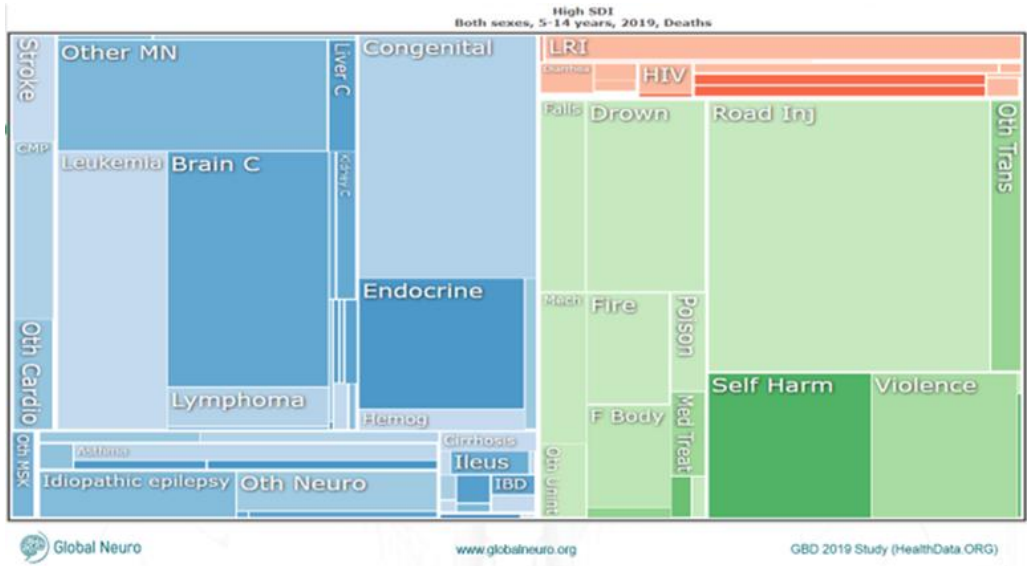


Global Burden of the Disease and the Human Developing Index



GBD - 2019


Global
Both sexes, All ages, 2019, Deaths
IHD
Stroke
Lung C
Stomach C
Neonatal
LRI
TB
Diarrhea
HIV
Malaria
HTN HD
CMP
A Fib
Diabetes
CKD
Cirrhosis
Falls
Road Inj
COPD
Asthma
Ileus
Alzheimer's
Parkinson's
Self Harm
Violence
Global Neuro
www.globalneuro.org
GBD 2019 Study (HealthData.ORG)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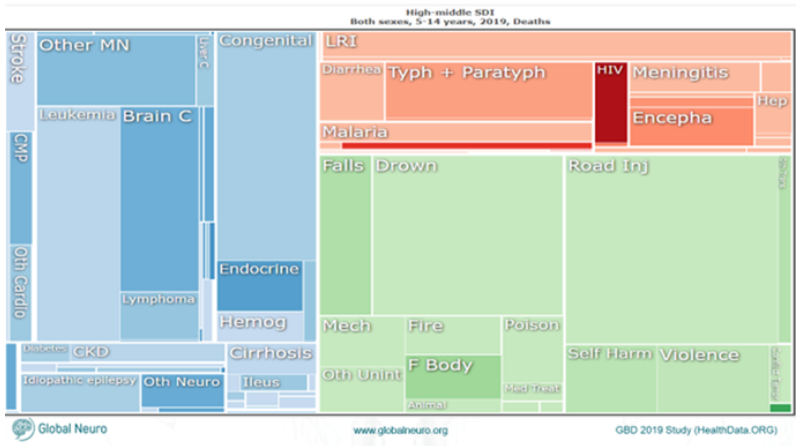
Ileus
Idiopathic epilepsy
Oth Neuro
Global Neuro
www.globalneuro.org
GBD 2019 Study (HealthData.ORG)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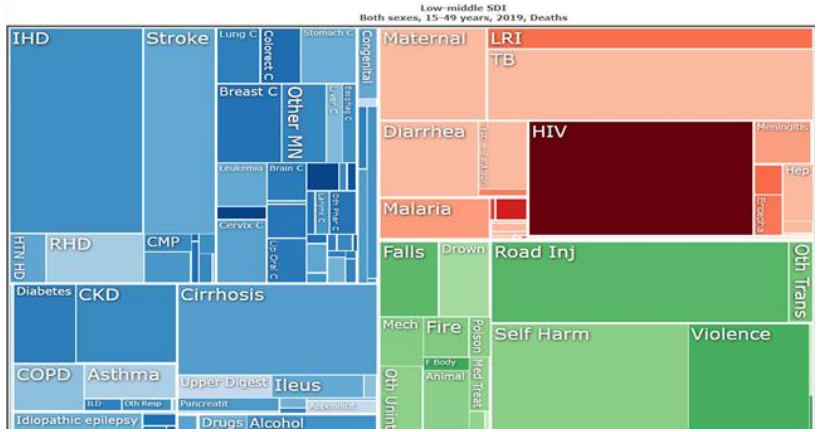
Low-middle SDI
Both sexes, 15-49 years, 2019, Deaths
IHD
Stroke
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LRI
TB
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Other MN
Diarrhea
HIV
RHD
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Malaria
Falls
Drown
Road Inj
Diabetes
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Cirrhosis
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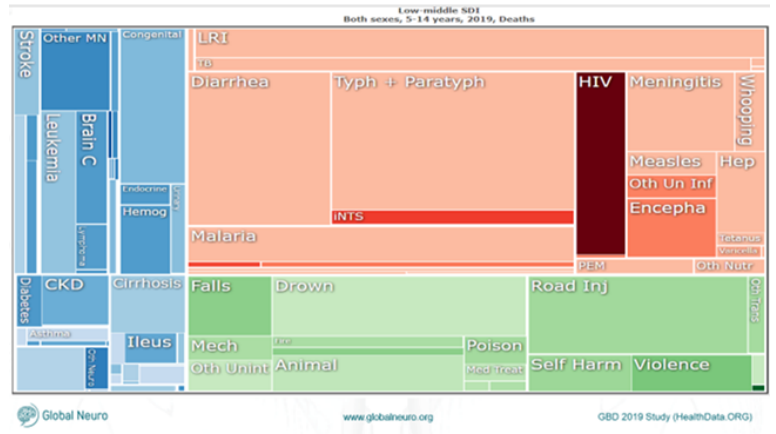
Low-middle SDI
Both sexes, 5-14 years, 2019, Deaths
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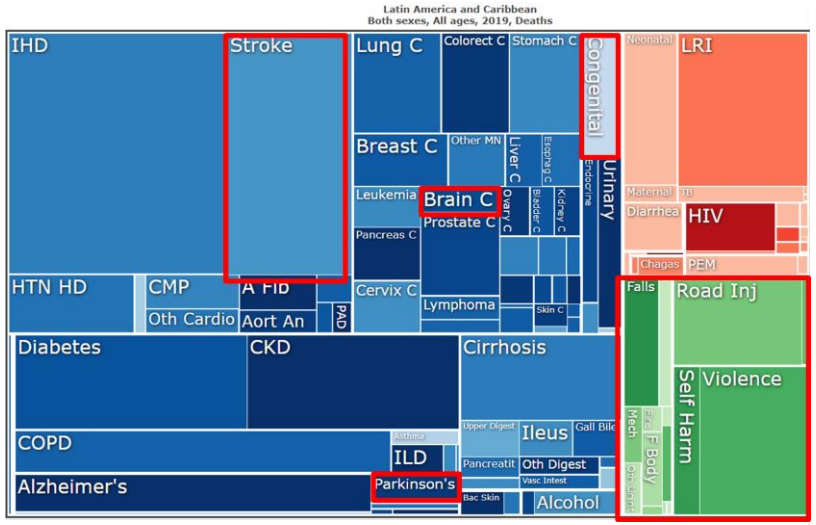
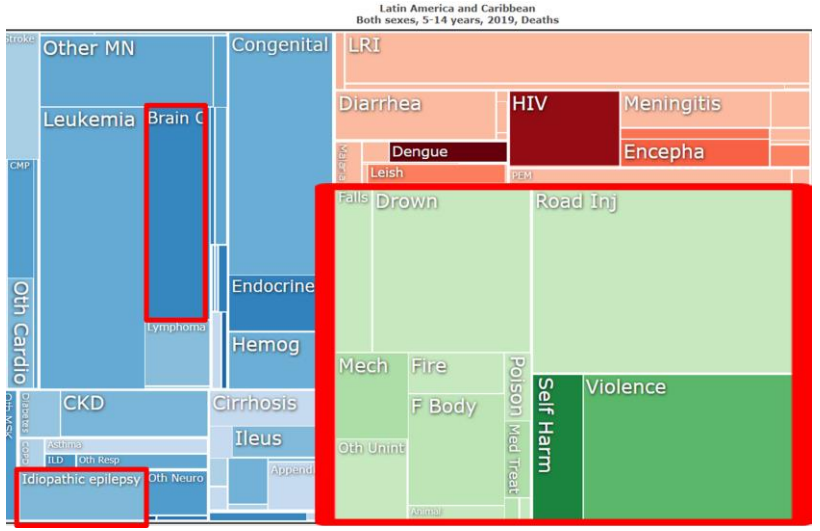
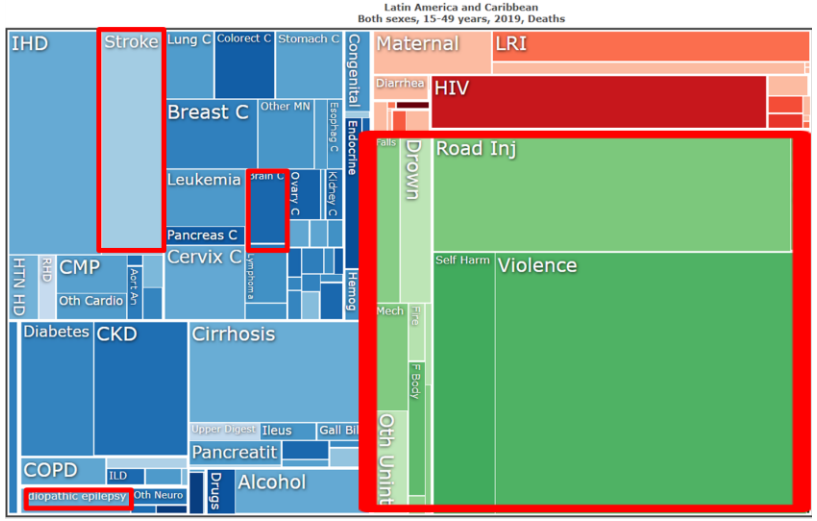
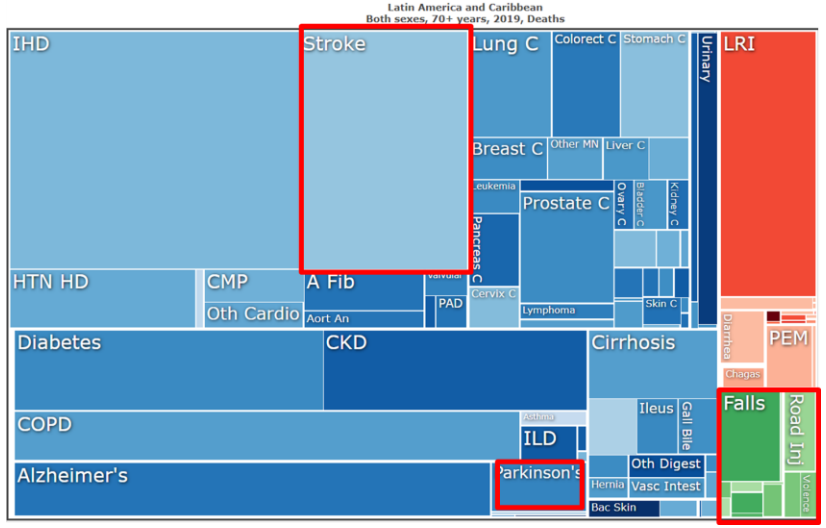
www.globalneuro.org
GBD 2019 Study (HealthData.ORG)

Latin American BD - 2019





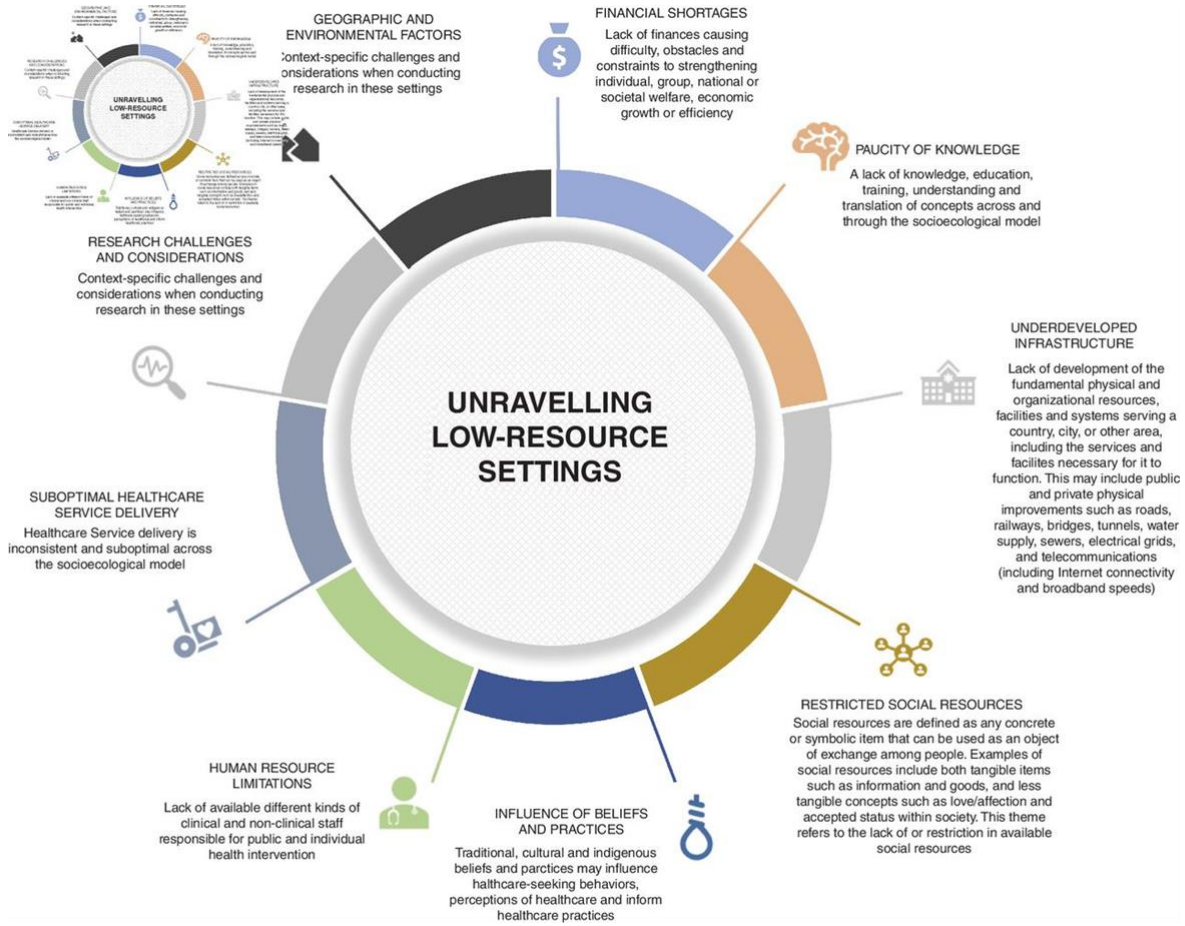


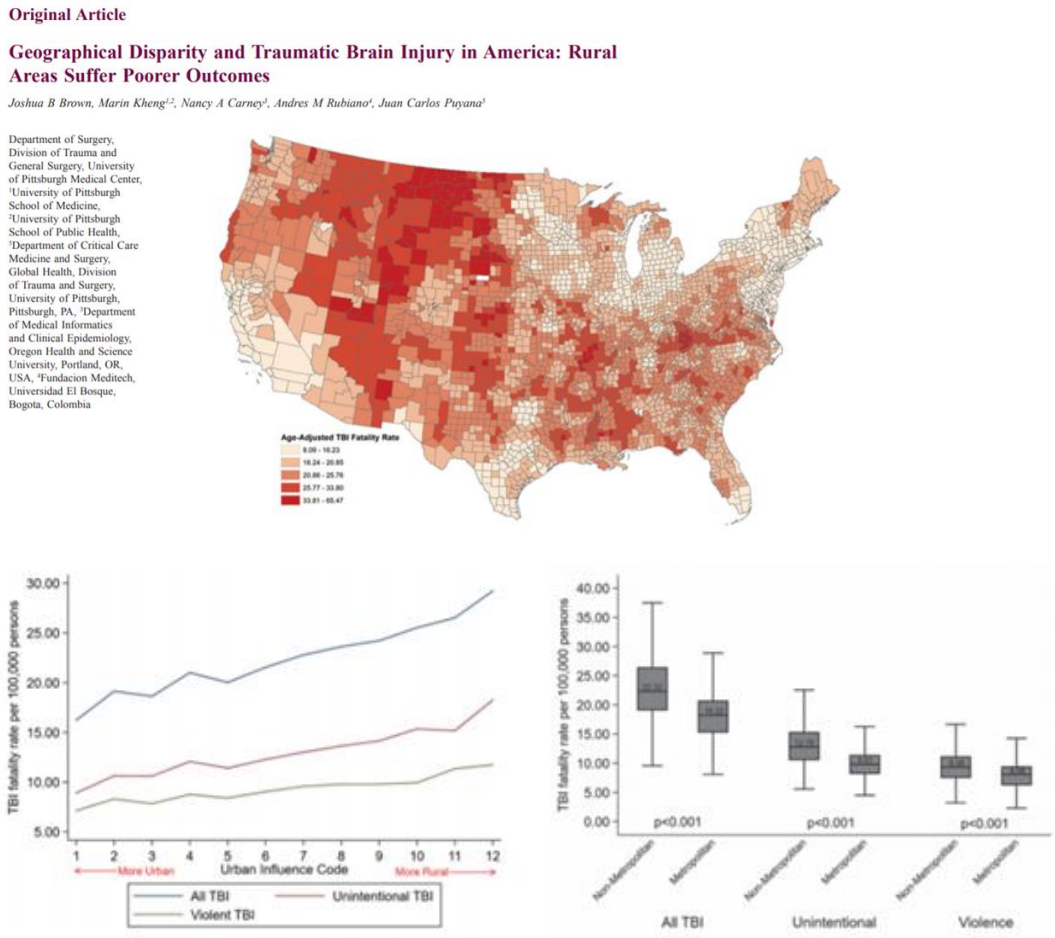


Neurotrauma is a Global Problem

- Neurotrauma is a global disease.
- Impact mostly the population between 5 to 45 y/old worldwide
- Low resourced areas (areas where the health system does not meet standardized criteria defined by multilateral organizations in the area, in terms of infrastructure, human resources or technology), are areas where quality of care and best practices are not always present (due to the lack of resources).

TBI Care in Low Resourced Areas





Van Zyl C, Badenhorst M, Hanekom S, et al Unravelling 'low-resource settings': a systematic scoping review with qualitative content analysis. BMJ Global Health 2021;6:e005190.

Brown JB, Kheng M, Carney NA, Rubiano AM, Puyana JC. Geographical disparity and traumatic brain injury in America: Rural areas suffer poorer outcomes. J Neurosci Rural Pract 2019;10:10-5

The Neurosurgeon and the Organized Trauma Care System

Neurotrauma Care and the Neurosurgeon: A Statement

This letter to the editor concerning trauma care is a modification of a similar report issued by the California Association of Neurological Surgeons and published in the Neurosurgical Forum in the October, 1986, issue of the *Journal of Neurosurgery*. — Editor.

To The Editor: A statement regarding neurotrauma care and the neurosurgeon was developed over the past several months with the efforts of a large number of neurosurgeons. It reflects organized neurosurgery's position on neurotrauma at this time. We think that this information deserves widespread distribution and also needs to be published in a permanent repository where it can be referred to at some future date. The statement was prepared by the Joint Section on Trauma of the American Association of Neurological Surgeons (AANS) and the Congress of Neurological Surgeons (CNS). It has been adapted from a California Association of Neurological Surgeons paper[1] and has been endorsed by the AANS and CNS governing bodies.

Lawrence H. Pitts, M.D.
Chairman, Joint Section on Trauma of the AANS and CNS
Robert G. Ojemann, M.D.
President, AANS
Donald O. Quest, M.D.
President, CNS

J. Neurosurg. / Volume 67 / November, 1987

The neurosurgeon and neurotrauma care system design.

Pitts Lh • Published 1988 • Medicine • Clinical neurosurgery

Neurotrauma and trauma systems.

L Pitts • Published 1995 • Medicine • New horizons

Optimal trauma care, including that for head and spinal cord injury, requires system organization and adoption throughout the United States and the world. Neurosurgeons play an essential role in system design and development in addition to treating neurotrauma patients. Areas of neurosurgical involvement include defining prehospital triage and treatment guidelines, emergency department evaluation and therapy, operative management, and active involvement in the critical care and acute hospital settings. Collaboration among all members of the trauma team is essential to ensure the best possible outcome for patients with traumatic injuries. Collapse

JOURNAL OF NEUROTRAUMA
Volume 13, Number 11, 1996
Mary Ann Liebert, Inc.

Trauma Systems and the Neurosurgeon

I. RECOMMENDATIONS

A. Standards

There are insufficient data to support a treatment Standard for this topic.

B. Guidelines

All regions in the United States should have an organized trauma care system.

C. Options

As delineated in the American College of Surgeons Committee on Trauma *Resources for Optimal Care of the Injured Patient: 1993*,[1] neurosurgeons should have an organized and responsive system of care for patients with neurotrauma. They should initiate neurotrauma care planning, including prehospital management and triage, maintain appropriate call schedules, review trauma care records for quality improvement, and participate in trauma education programs.

Brain Injury, March 2013; 27(3): 262–272

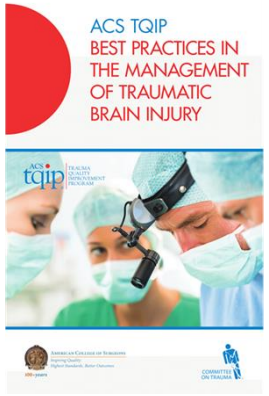
Strengthening neurotrauma care systems in low and middle income countries

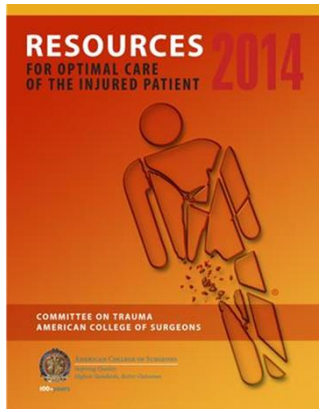
ANDRES M. RUBIANO[1,2], JUAN C. PUYANA[3,4], CHARLES N. MOCK[5,6], M. ROSS BULLOCK[7], & P. DAVID ADELSON[8]

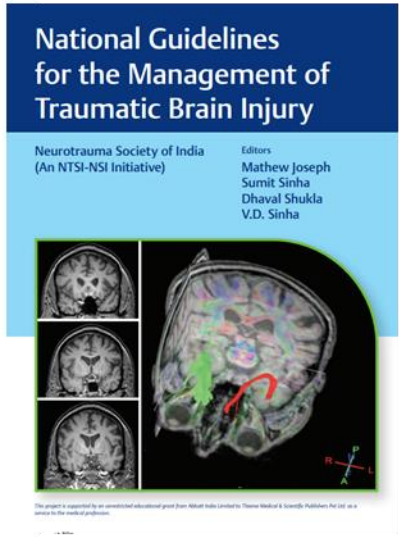
Table I. Requirements to consider for a neurotrauma centre to offer optimal care of the patient [14].

Minimum requirements for a reference neurotrauma care centre
1. Computed Tomography available 24 hours a day.
2. Neurosurgeon available 24 hours a day (time of on call arrival less than 15 minutes).
3. Immediate availability of operating room.
4. Immediate availability of intensive care unit with an intensive care physician. *(Neuromonitoring is recommended)
5. Availability of other specialties for advanced care of trauma patient (general surgery, orthopaedic surgery, plastic surgery, etc.).

Quality of Care and Guided Care Therapies in Neurotrauma







Performance of Providers for Working Within Organized Care Systems

Krijgsheld *et al. BMC Health Services Research* (2022) 22:149
https://doi.org/10.1186/s12913-021-07357-5

BMC Health Services Research

RESEARCH ARTICLE Open Access

Job performance in healthcare: a systematic review

Marcel Krijgsheld[1*], Lars G. Tummers[1] and Floortje E. Scheepers[2]

Understanding the Context In Which You Lead is Crucial !!

Table 7 Factors affecting job performance on the macro-, meso-, and micro-levels

Level	Factors that positively affect performance	Factors that negatively affect performance
Macro (organisation)	Organisational support Organisational structure Involved organisational culture	Toxic climate/culture Abusive supervision Turnover of high-performing employees
Meso (management/team)	Team structure Perceived interdependence Social supports	Abusive supervision Limited resources Heavy workloads Dissatisfaction with co-workers
Micro (individual)	Work engagement Role clarity Autonomy Skills and level of education Personal characteristics (openness to change, extraversion, eagerness, and creativity)	Low emotional intelligence Machiavellianism Burnout

Task performance	Has a direct relationship to an organisational technical core and refers to direct or indirect activities that are formally part of a worker's job
Contextual performance	Maintains the broader organisational, social, and psychological environments in which a technical core must function
Adaptive performance	The extent to which an individual adapts to changes in work systems or work roles
Counterproductive work behaviour	Behaviour that is harmful to the well-being of an organisation

Performance of Dedicated Specialists in Trauma Care

Cochrane Library

Trusted evidence.
Informed decisions.
Better health.

Cochrane Database of Systematic Reviews

[Intervention Protocol]

Organised trauma systems and designated trauma centres for improving outcomes in injured patients

Michael Mwandri[1], Barclay Stewart[2,3], Timothy C Hardcastle[4,5], Andres M Rubiano[6], Russell L Gruen[7]

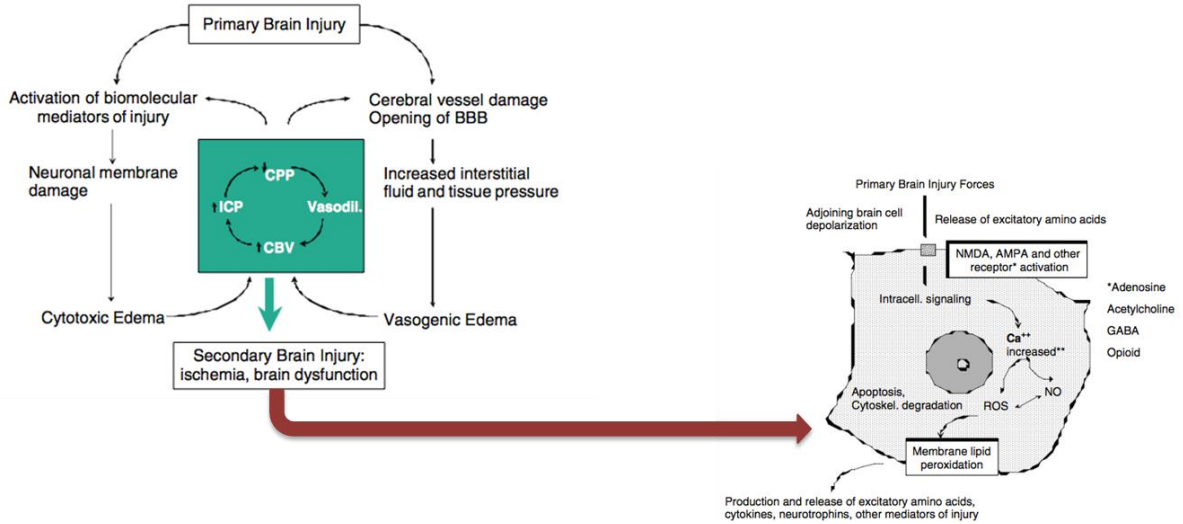
TABLE 5. Overall Mortality According to Level of ACS Trauma Center Designation

ACS Level	Unadjusted Mortality	Adjusted OR* (95% CI)	*P* Value
I	1253/4948 (25.3%)	0.81 (0.71–0.94)	0.004
II	408/1393 (29.3%)		
I	1253/4948 (25.3%)	0.82 (0.75–0.89)	0.000
All other centers	2093/7306 (28.6%)		
II	408/1393 (29.3%)	1.0 (0.87–1.15)	0.954
Other (III, IV, not designated)	1685/5913 (28.5%)		

*Adjusted for age (≤65 or >65 yr), mechanism of injury (blunt or penetrating), hypotension on admission (systolic <90 mm Hg), injury severity score >25 or ≤25.
ACS indicates American College of Surgeons; OR, odds ratio; CI, confidence interval.

- Sub-specialized physicians generate a context of knowledge with high levels of skills and experience through the management of significant volumes of patients, BUT SPECIALLY in places where academia, research and the concentration of resources and equipment lead to better decision making and multidisciplinary integration with other concurrent specialties.

Evolution of Basic Concepts in Neurotrauma



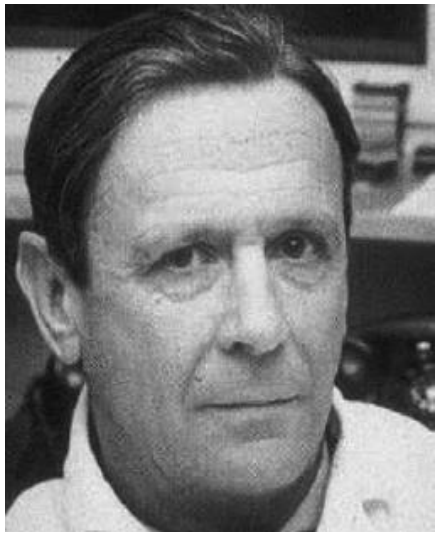
- Traditionally, within the classic scheme of understanding traumatic brain injury, two concepts have been used:
  - **Primary Injury:** damage to bone, vessels and neural tissue because of an external mechanical force.
  - **Secondary Injury:** processes after the primary injury that include physiological alterations (inflammatory, neurochemical, metabolic) in the brain tissue.

Namjoshi DR, Good C, Cheng WH, Panenka W, Richards D, Cripton PA, Wellington C: Towards clinical management of traumatic brain injury: a review of models and mechanisms from a biomechanical perspective. Dis Model Mech. 2013: 6(6), 1325-1338

Greve MW, Zink BJ: Pathophysiology of Traumatic Brain Injury, Mount Sinai J of Medicine, 2009: 76:, 97-174

Prins M, Greco T, Alexander D, Giza CC. The pathophysiology of traumatic brain injury at a glance. Dis. Model Mech. 2013: 6(6); 1307-1315.

Evolution of Basic Concepts in Neurotrauma



Nils Lundberg, 1959 (ICP)
Sweden

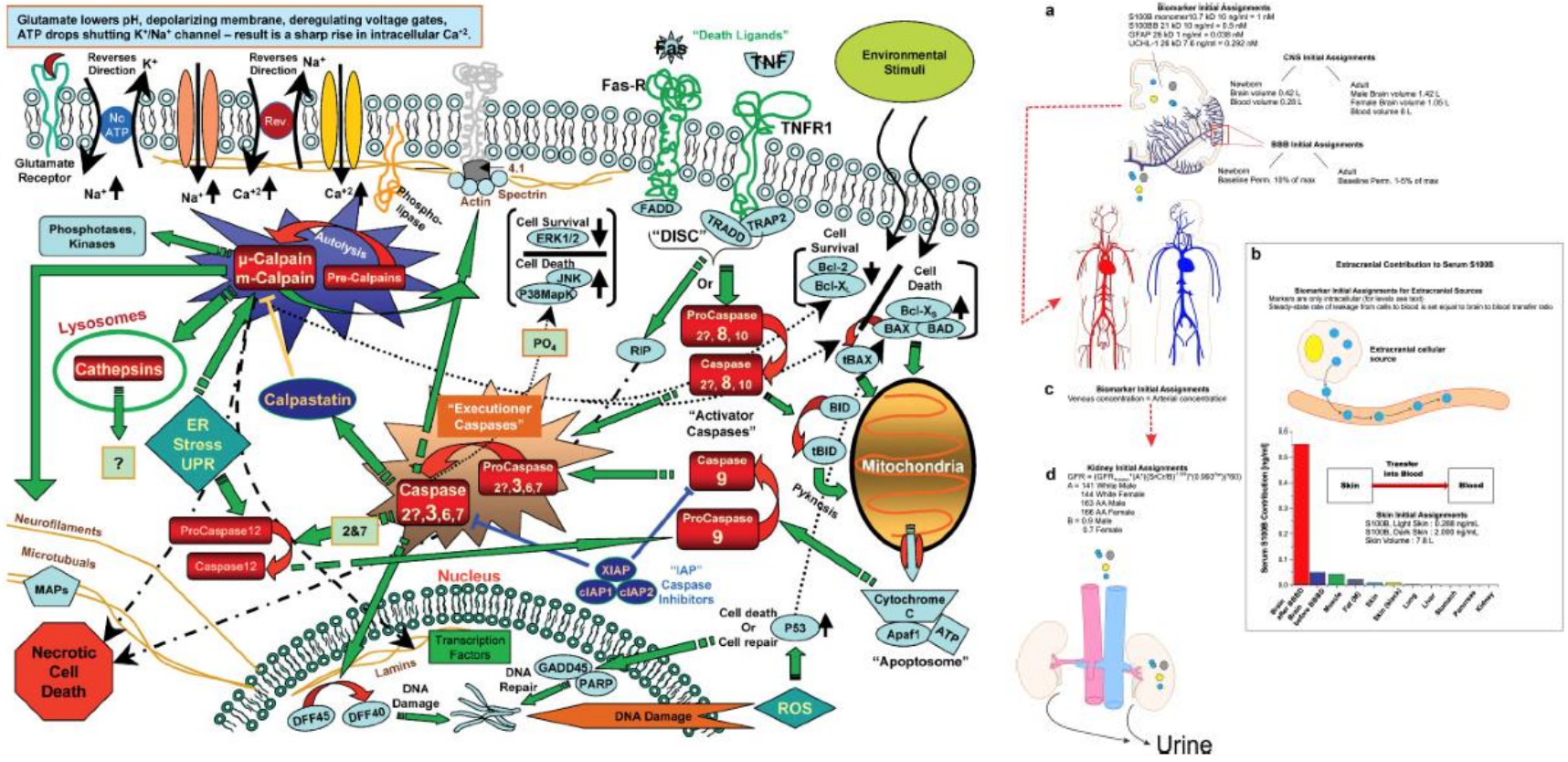
Niels Lassen, 1962 (CBF)
Denmark

Bo Siesjö, 1962 (Cerebral Metabolism)
Sweden

- These models of understanding TBI concepts emerged from works at the early research laboratories in physiology and monitoring of brain injury in the 50s and 60s in Europe.

Nordstrom CH, Nielsen TH, Jacobsen A. Techniques and strategies in neurocritical care originating from southern Scandinavia. J. Rehab. Med. 2013: 45; 110-117.

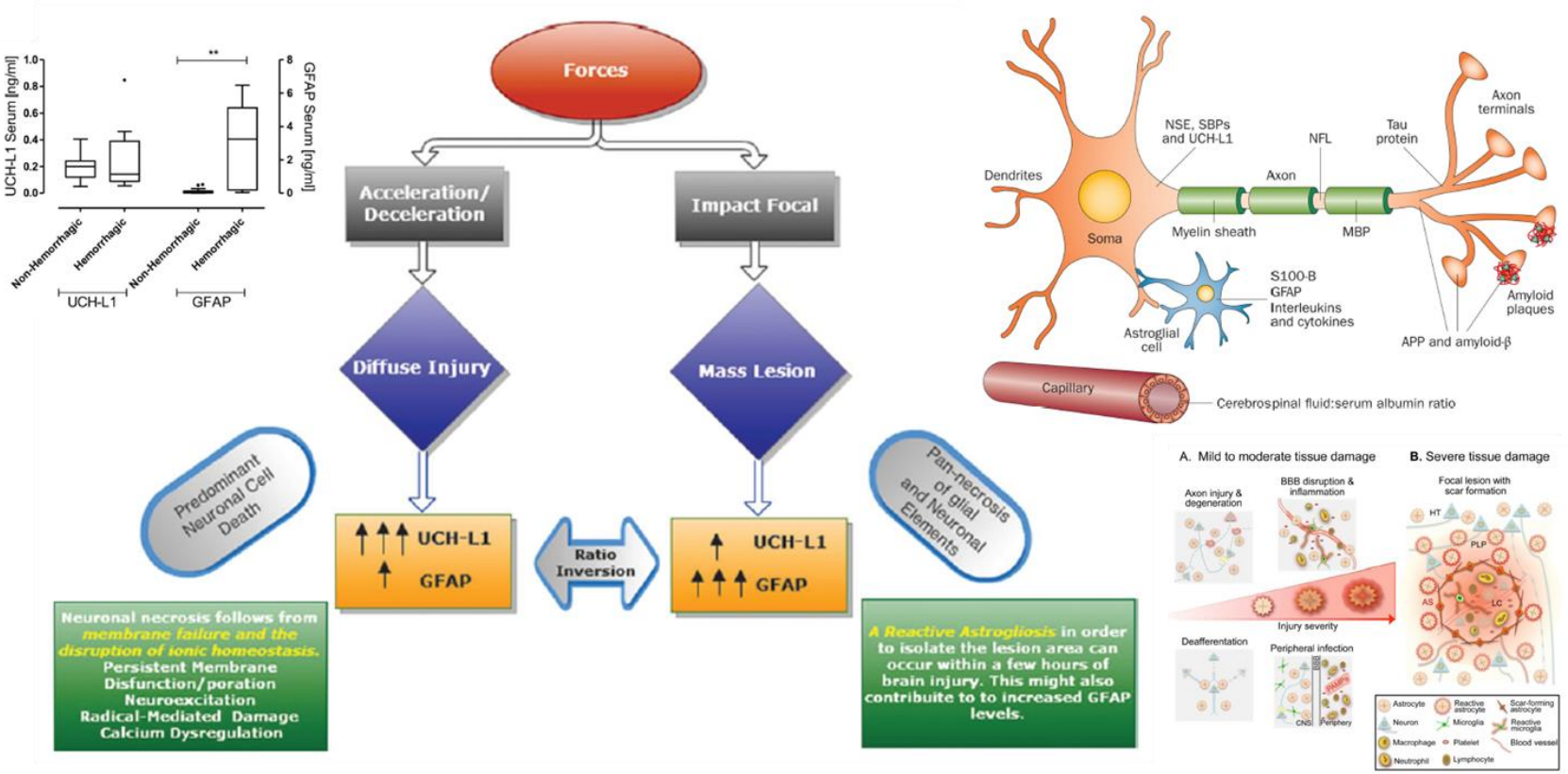
Neuroproteomics In Neurotrauma



Ottens et al. Neuroproteomics in Neurotrauma. Mass Spectrometry Reviews, 2006, 25, 380– 408

Dadas A et al. Improving the clinical management of traumatic brain injury through the pharmacokinetic modeling of peripheral Blood biomarkers. Fluids and Barriers of the CNS, 2016: 13(21): 1-12

Neurodegradomics in Neurotrauma



Mondello S, et al. Glial Neuronal Ratio: A Novel Index for Differentiating Injury Type in Patients with Severe Traumatic Brain Injury. J Neurotrauma. 2012;29: 1096-1104.

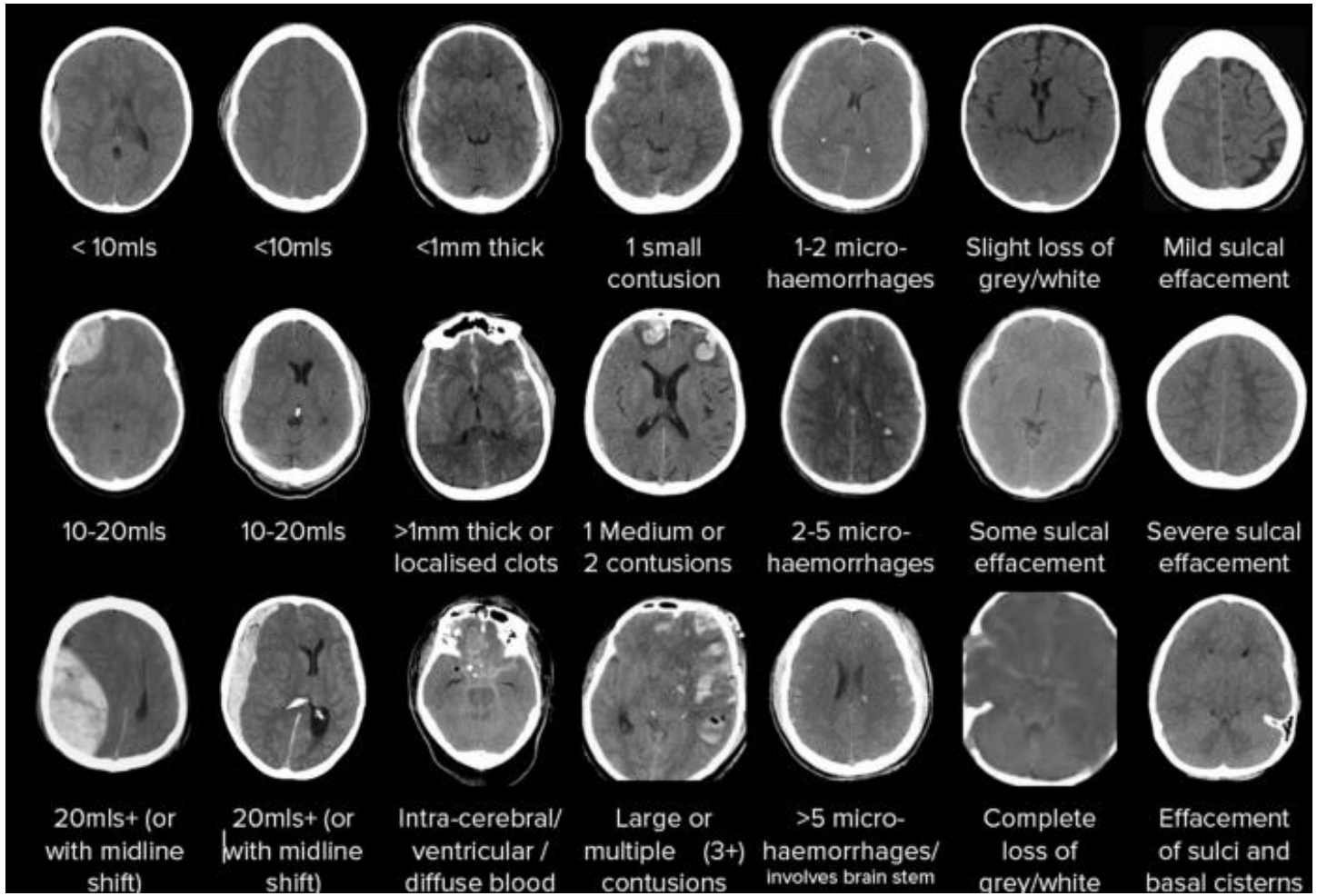
Zetterberg H et al. Biomarkers of mild traumatic brain injury in cerebrospinal fluid and blood. Nat. Rev. Neurol. 2013: 9(4): 201-210.

Dambinova SA: Neurodegradomics: the source of biomarkers for mild TBI. In: Biomarkers for TBI, Chapter 4, pp 66–86. Edited by Dambinova SA, Hayes RL, Wang KW. London, UK, Royal Society of Chemistry Publishing, 2012.

The Era of Biomarkers in TBI

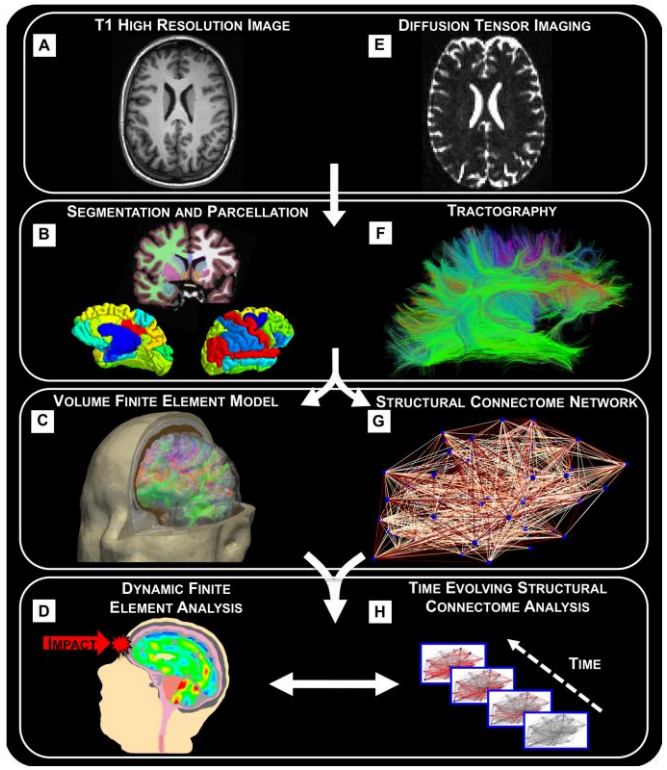
Events	Mechanism	Candidate Serum Biomarkers		
		Mild TBI	Moderate TBI	Severe TBI
Neuronal and Glial Cell Death	Activation of factors triggering necrosis and/or apoptosis	Neuronal: NSE, C-tau, SBP, AII-Spectrin	Neuronal: NSE, pNF-H, NF-H, NMDAR, Hsp70, UCH-L1, C-tau, AII-spectrin, SBP, Secretagogin	Neuronal: NSE, pNF-H, NF-H, NMDAR, Hsp70, UCH-L1, C-tau, AII-spectrin, SBP, Secretagogin
		Glial: S100β , GFAP, MBP, C-tau	Glial: S100β, GFAP, MBP, NMDAR, Hsp70, IL-1β, IL-6, IL-8, TN- α, C-tau, AQP4	Glial: S100β, GFAP, MBP, NMDAR, Hsp70, IL-1β, IL-6, IL-8, TN- α, C -tau, AQP4
Vasospasm	Dysregulation of vascular constriction and relaxation	-	Hsp70, TNF-α, VEGF, Claudin-5, vWF	Hsp70, TNF-α, VEGF, Claudin-5, vWF
Edema	Vasogenic and cytotoxic events caused by toxic and inflammatory factors	-	Hsp70, IL-1β, IL -6, IL-8, VEGF, Claudin-5, vWF, AQP4, MMP9	Hsp70, IL-1β, IL -6, IL-8, VEGF, Claudin-5, vWF, AQP4, MMP9
Axonal Injury	Mechanical injury; Neuronal degeneration	S100β, NSE, C-tau, MBP, SBP, AII-Spectrin	S100β, MBP, NSE, PNF-H, NMDAR, Hsp70, C-tau, AII-spectrin, SBP	S100β, MBP, NSE, PNF-H, NMDAR, Hsp70, C-tau, AII-spectrin, SBP
Inflammation	Cytokine release and cellular stress	IL-1β, IL -6, IL-8, TNF-α, IFN -γ	Hsp70,IL-1β, IL-6, IL-8, TNF-α, IFN -γ	Hsp70,IL-1β, IL -6, IL-8, TNF-α, IFN -γ
Metabolic Changes	Hypoxia; altered energy demand, ion homeostasis and neurotransmission; increased repair processes	-	Ceruloplasmin, HIF-1α	Ceruloplasmin, HIF-1α

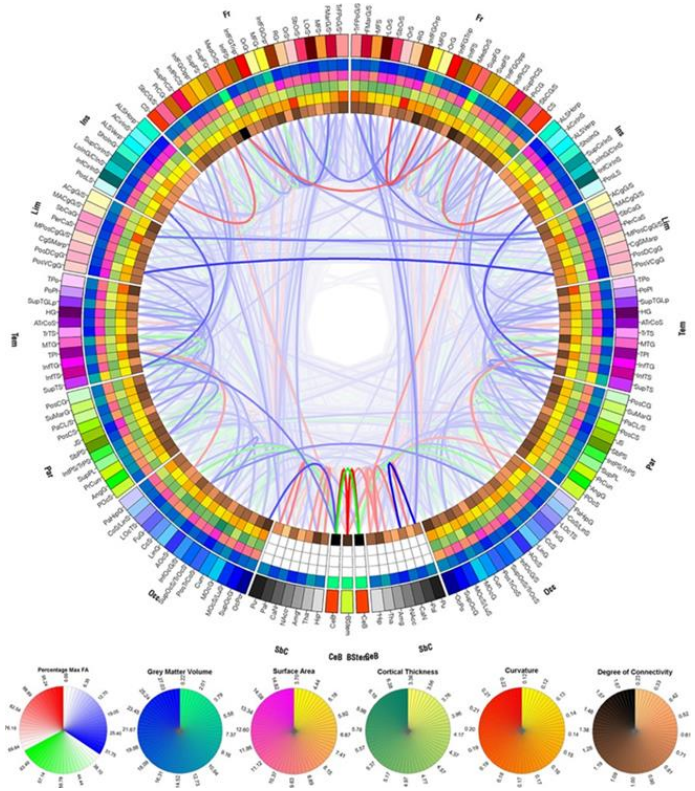
Bogoslovsky T, et al. Fluid biomarkers of Traumatic Brain Injury and Intended Context of Use. Diagnostics (Basel), 2016: 6(4), 37-41.



Wilson MH, Ashworth E, Hutchinson PJ; British Neurotrauma Group. A proposed novel traumatic brain injury classification system - an overview and inter-rater reliability validation on behalf of the Society of British Neurological Surgeons. Br J Neurosurg. 2022 Oct;36(5):633-638

Conectomics In Neurotrauma

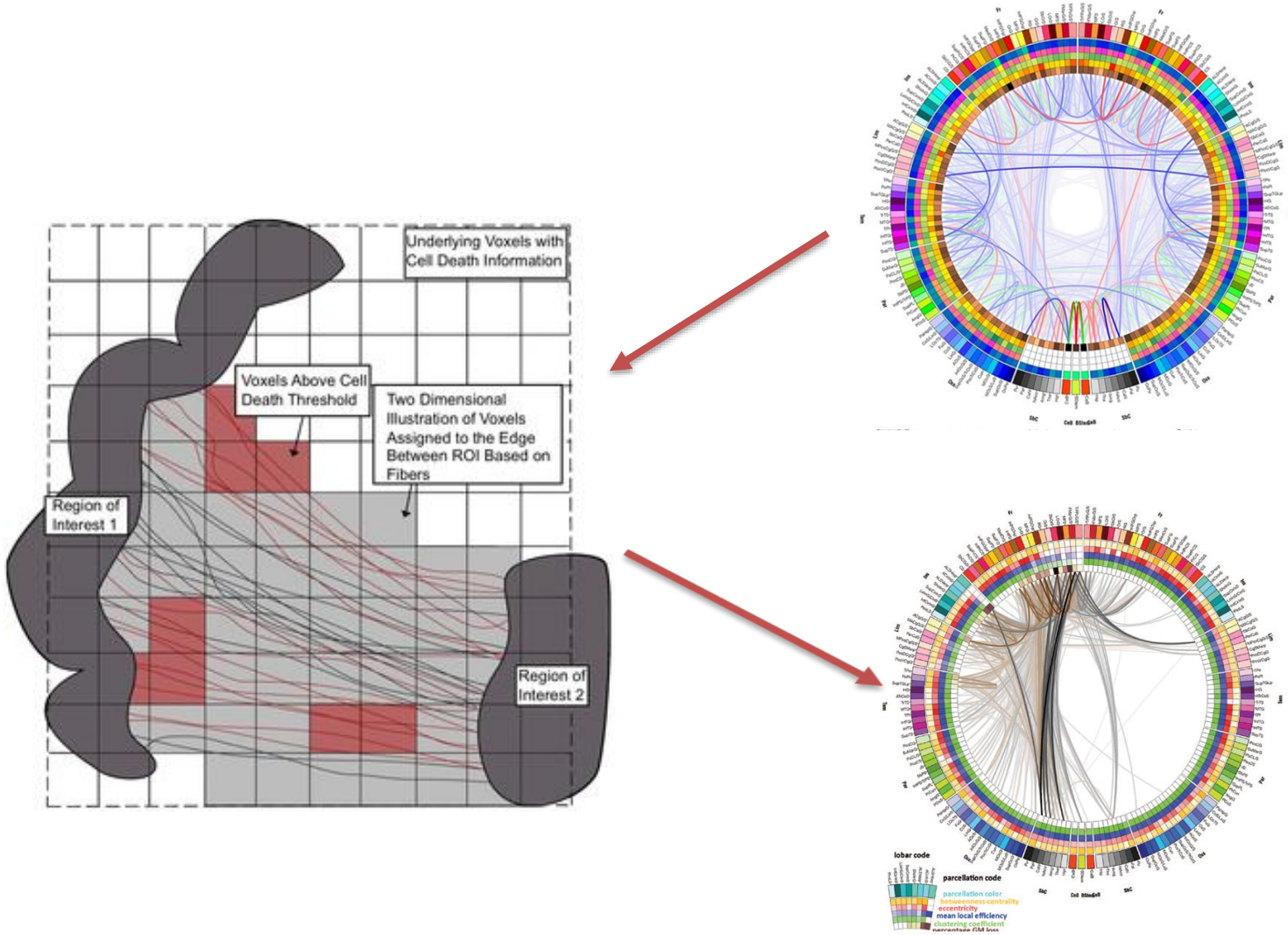




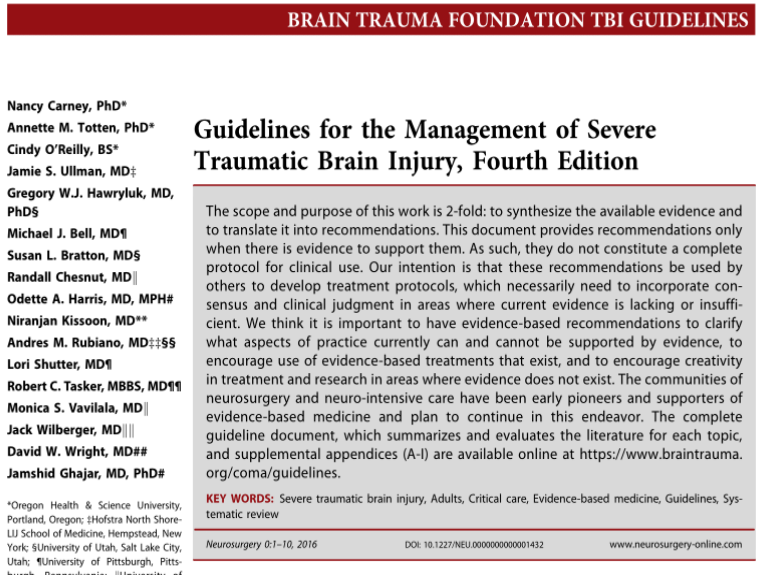
Connectomics is a hybrid discipline resulting from the fusion of neuroimaging acquisition and analysis techniques based on resonance sequences with network theory.

Kraft RH, McKee PJ, Dagro AM, Grafton ST. Combining the finite element method with structural connectome-based analysis for modeling neurotrauma: connectome neurotrauma mechanics. PLoS Comput Biol. 2012;8(8):e1002619

Connectomics in Neurotrauma



Section 2: Objective 2



BRAIN TRAUMA FOUNDATION TBI GUIDELINES

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Guidelines for the Management of Severe Traumatic Brain Injury, Fourth Edition

The scope and purpose of this work is 2-fold: to synthesize the available evidence and to translate it into recommendations. This document provides recommendations only when there is evidence to support them. As such, they do not constitute a complete protocol for clinical use. Our intention is that these recommendations be used by others to develop treatment protocols, which necessarily need to incorporate consensus and clinical judgment in areas where current evidence is lacking or insufficient. We think it is important to have evidence-based recommendations to clarify what aspects of practice currently can and cannot be supported by evidence, to encourage use of evidence-based treatments that exist, and to encourage creativity in treatment and research in areas where evidence does not exist. The communities of neurosurgery and neuro-intensive care have been early pioneers and supporters of evidence-based medicine and plan to continue in this endeavor. The complete guideline document, which summarizes and evaluates the literature for each topic, and supplemental appendices (A-I) are available online at https://www.braintrauma.org/coma/guidelines.

KEY WORDS: Severe traumatic brain injury, Adults, Critical care, Evidence-based medicine, Guidelines, Systematic review

Neurosurgery 0:1–10, 2016 DOI: 10.1227/NEU.0000000000001432 www.neurosurgery-online.com

Guidelines for the Management of Severe Traumatic Brain Injury. Neurosurgery, 2016.

Acta Neurochirurgica (2019) 161:1261–1274
https://doi.org/10.1007/s00701-019-03936-y

REVIEW ARTICLE - CONFERENCE REPORT

Check for updates

Consensus statement from the International Consensus Meeting on the Role of Decompressive Craniectomy in the Management of Traumatic Brain Injury

Consensus statement

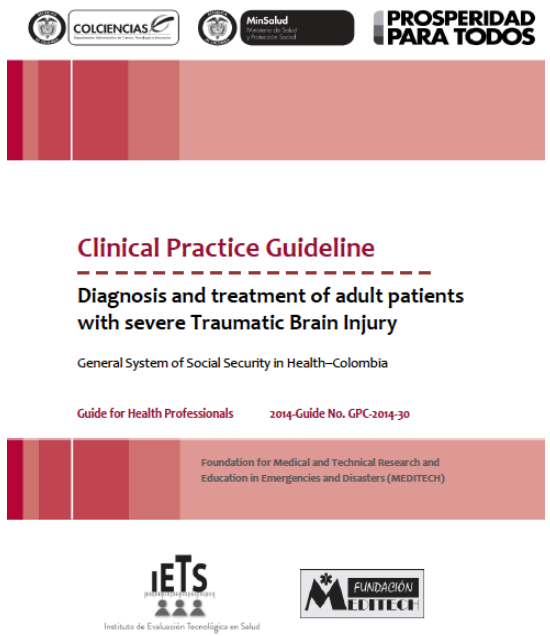
Peter J. Hutchinson[1,2] · Angelos G. Kolias[1,2] · Tamara Tajsic[1,2] · Amos Adeleye[3,4] · Abenezer Tirsit Aklilu[5,6] · Tedy Apriawan[7] · Abdul Hafid Bajamal[7] · Ernest J. Barthélemy[8] · B. Indira Devi[9] · Dhananjaya Bhat[9] · Diederik Bulters[10] · Randall Chesnut[11] · Giuseppe Citerio[12,13] · D. Jamie Cooper[14,15] · Marek Czosnyka[1] · Idara Edem[16] · Nasser M.F. El-Ghandour[17] · Anthony Figaji[18] · Kostas N. Fountas[19] · Clare Gallagher[20] · Gregory W.J. Hawryluk[21] · Corrado Iaccarino[22] · Mathew Joseph[23] · Tariq Khan[24] · Tsegazeab Laeke[5,6] · Oleg Levchenko[25] · Baiyun Liu[26] · Weiming Liu[26] · Andrew Maas[27] · Geoffrey T. Manley[28] · Paul Manson[29] · Anna T. Mazzeo[30] · David K. Menon[31] · Daniel B. Michael[32] · Susanne Muehlschlegel[33] · David O. Okonkwo[34] · Kee B. Park[35] · Jeffrey V. Rosenfeld[36,37] · Gail Rosseau[38] · Andres M. Rubiano[39,40] · Hamisi K. Shabani[41] · Nino Stocchetti[42,43] · Shelly D. Timmons[44] · Ivan Timofeev[1] · Chris Uff[45,46] · Jamie S. Ullman[47] · Alex Valadka[48] · Vicknes Waran[49] · Adam Wells[50] · Mark H. Wilson[51] · Franco Servadei[52]

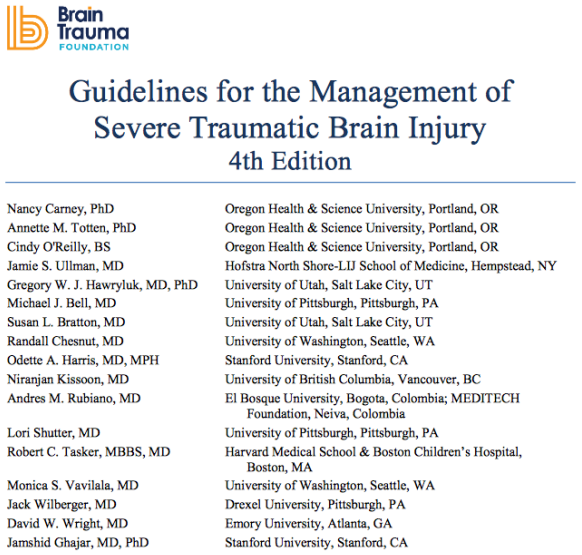
Received: 15 April 2019 / Accepted: 29 April 2019 / Published online: 28 May 2019

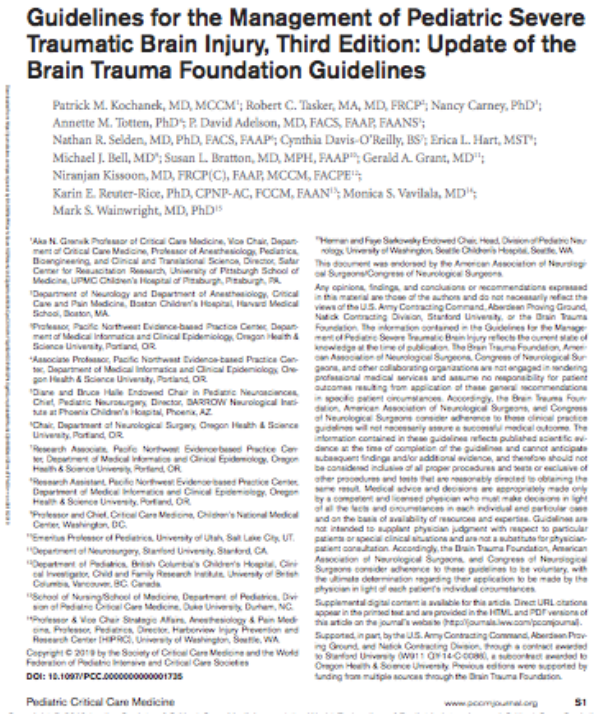
Consensus statement from the International Consensus Meeting on the Role of Decompressive Craniectomy in the Management of Traumatic Brain Injury : Consensus statement. Acta Neurochir (Wien). 2019 Jul;161(7):1261-1274

"Discuss present trends in the process of diagnosis and decision-making for the comprehensive management of TBI based on scientific evidence and expert consensus".

Evidence Based Clinical Practice Guidelines







Difficulties in Knowledge Transferability and Applicability

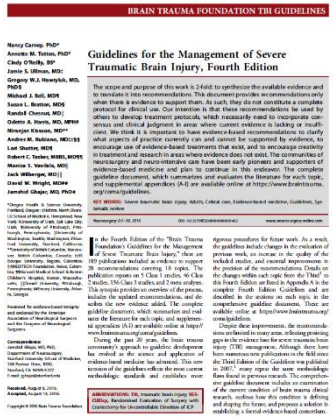
- Cerebrospinal Fluid Drainage – Level III (Low Quality of Evidence):
  - An EVD system zeroed at the midbrain with continuous drainage of CSF may be considered to lower ICP burden more effectively than intermittent use.
  - Use of CSF drainage to lower ICP in patients with an initial GCS<6 during the first 12 hours after injury may be considered.

COMPONENTS OF OVERALL QUALITY – Class 3

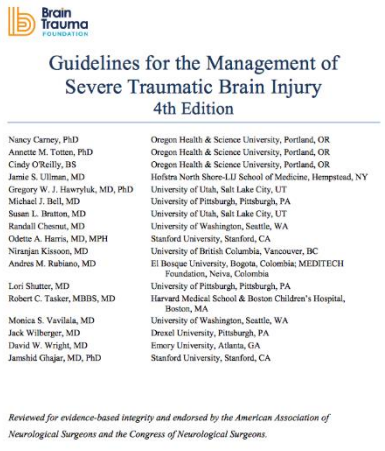
Topic	Number of Studies	Meta-Analysis	Number of Subjects	Class of Studies	Consistency (High, Moderate, Low)	Directness (Direct or indirect)	Precision (High, Moderate, Low)	Quality of Evidence (High, Moderate, Low, or Insufficient)
Continuous vs. intermittent CSF drainage[3]	1 Retrospective cohort	NA	82	3	NA	Direct	Low	Low
Use of CSF drainage[4]	1 Retrospective cohort	NA	171	3	NA	Direct	Low	Low

*Of 12 new, potentially relevant studies reviewed, 10 were excluded because they did not meet the inclusion criteria for this topic.

*No Class 1 or 2 evidence was identified; two new Class 3 studies were included.


BRAIN TRAUMA FOUNDATION TBI GUIDELINES

Guidelines for the Management of Severe Traumatic Brain Injury, Fourth Edition


Brain Trauma Foundation

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

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Jamie S. Ullman, MD	Hofstra North Shore-LIJ School of Medicine, Hempstead, NY
Gregory W. J. Hawryluk, MD, PhD	University of Utah, Salt Lake City, UT
Michael J. Bell, MD	University of Pittsburgh, Pittsburgh, PA
Susan L. Bratton, MD	University of Utah, Salt Lake City, UT
Randall Chesnut, MD	University of Washington, Seattle, WA
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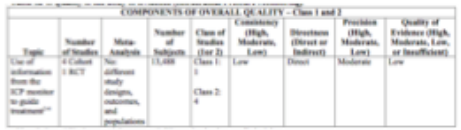
Jack Wilberger, MD	Drexel University, Pittsburgh, PA
David W. Wright, MD	Emory University, Atlanta, GA
Jamshid Ghajar, MD, PhD	Stanford University, Stanford, CA

Reviewed for evidence-based integrity and endorsed by the American Association of Neurological Surgeons and the Congress of Neurological Surgeons.

- Intracranial Pressure (ICP) Monitoring (Level IIB):
  - **Management of severe traumatic brain injury (TBI) patients using information from ICP monitoring is recommended to reduce in-hospital and 2-week post-injury mortality.**

*What is clear from the literature is that intracranial hypertension is an important secondary insult after severe TBI, and its alleviation plays a pivotal role in providing good patient care to achieve optimal outcomes.


COMPONENTS OF OVERALL QUALITY – Class 1 and 2

Topic	Number of Studies	Meta-Analysis	Number of Subjects	Class of Studies (1or 2)	Consistency (High, Moderate, Low)	Directness (Direct or Indirect)	Precision (High, Moderate, Low)	Quality of Evidence (High, Moderate, Low, or Insufficient)
Use of information from the ICP monitor to guide treatment[1]	4 Cohort 1 RCT	No: different study designs, outcomes, and populations	13,488	Class 1: 1 Class 2: 4	Low	Direct	Moderate	Low

It is important to acknowledge that clinical practice in most high-income countries incorporates multiple monitoring approaches. As such, treatment decisions are not made using one source of information in isolation.

In low-and- middle-income countries often medical decisions may be driven by clinical assessment alone.

Therefore, the application of these guidelines will vary depending upon the medical environment in which they are used.

The Class 1 RCT was conducted in countries with very limited pre-hospital care, and where monitors are not common. This has raised concerns about applicability for some researchers and clinicians.

Expert Consensus: Filling Gaps in Evidence

Acta Neurochirurgica
https://doi.org/10.1007/s00701-019-03936-y

REVIEW ARTICLE - CONFERENCE REPORT

Check for updates

Consensus statement from the International Consensus Meeting on the Role of Decompressive Craniectomy in the Management of Traumatic Brain Injury

Consensus statement

Peter J. Hutchinson[1,2] · Angelos G. Kolias[1,2] · Tamara Tajsic[1,2] · Amos Adeleye[3,4] · Abenezer Tirsit Aklilu[5,6] · Tedy Apriawan[7] · Abdul Hafid Bajamal[7] · Ernest J. Barthélemy[8] · B. Indira Devi[9] · Dhananjaya Bhat[9] · Diederik Bulters[10] · Randall Chesnut[11] · Giuseppe Citerio[12,13] · D. Jamie Cooper[14,15] · Marek Czosnyka[1] · Idara Edem[16] · Nasser M.F. El-Ghandour[17] · Anthony Figaji[18] · Kostas N. Fountas[19] · Clare Gallagher[20] · Gregory W.J. Hawryluk[21] · Corrado Iaccarino[22] · Mathew Joseph[23] · Tariq Khan[24] · Tsegazeab Laeke[5,6] · Oleg Levchenko[25] · Baiyun Liu[26] · Weiming Liu[26] · Andrew Maas[27] · Geoffrey T. Manley[28] · Paul Manson[29] · Anna T. Mazzeo[30] · David K. Menon[31] · Daniel B. Michael[32] · Susanne Muehlschlegel[33] · David O. Okonkwo[34] · Kee B. Park[35] · Jeffrey V. Rosenfeld[36,37] · Gail Rosseau[38] · Andres M. Rubiano[39,40] · Hamisi K. Shabani[41] · Nino Stocchetti[42,43] · Shelly D. Timmons[44] · Ivan Timofeev[1] · Chris Uff[45,46] · Jamie S. Ullman[47] · Alex Valadka[48] · Vicknes Waran[49] · Adam Wells[50] · Mark H. Wilson[51] · Fran[illegible][52]

Acta Neurochirurgica (2021) 163:423–440
https://doi.org/10.1007/s00701-020-04663-5

REVIEW ARTICLE - CONFERENCE REPORT

Check for updates

Consensus statement from the international consensus meeting on post-traumatic cranioplasty

C. Iaccarino[1] · A. Kolias[2,3] · P. D. Adelson[4] · A. M. Rubiano[5] · E. Viaroli[2] · A. Buki[6] · G. Cinalli[7] · K. Fountas[8] · T. Khan[9] · S. Signoretti[10] · V. Waran[11] · A. O. Adeleye[12] · R. Amorim[13] · A. Bertuccio[14] · A. Cama[15] · R. M. Chesnut[16,17] · P. De Bonis[18] · A. Estraneo[19,20] · A. Figaji[21] · S. I. Florian[22] · R. Formisano[23] · P. Frassanito[24] · C. Gatos[25] · A. Germanò[26] · C. Giussani[27] · I. Hossain[28] · P. Kasprzak[29] · F. La Porta[30] · D. Lindner[31] · A. I. R. Maas[32] · W. Paiva[33] · P. Palma[34] · K. B. Park[35] · P. Peretta[36] · A. Pompucci[37] · J. Posti[38] · S. K. Sengupta[39] · A. Sinha[40] · V. Sinha[41] · R. Stefini[42] · G. Talamonti[43] · A. Tasiou[25] · G. Zona[44,45] · M. Zucchelli[46] · P. J. Hutchinson[2] · F. Servadei[47,48]

Consensus Based – Algorithm: Management of TBI with Polytrauma in Middle/High Resourced Settings

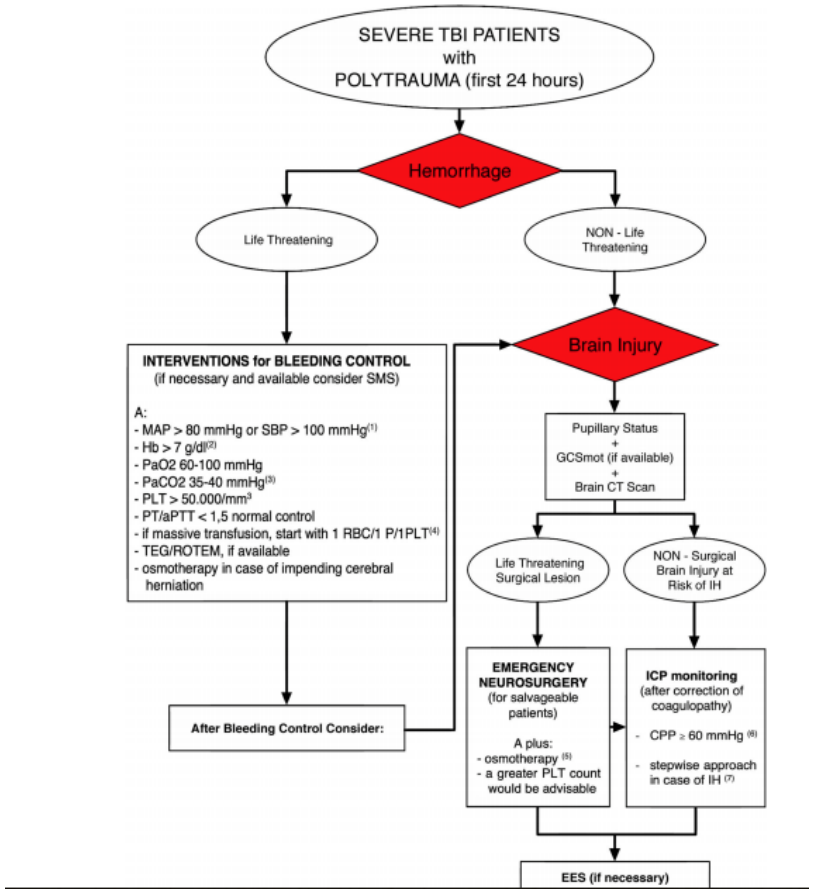
Picetti *et al. World Journal of Emergency Surgery* (2019) 14:53
https://doi.org/10.1186/s13017-019-0270-1

World Journal of Emergency Surgery

REVIEW Open Access

WSES consensus conference guidelines: monitoring and management of severe adult traumatic brain injury patients with polytrauma in the first 24 hours

Edoardo Picetti[1*], Sandra Rossi[1], Fikri M. Abu-Zidan[2], Luca Ansaloni[3], Rocco Armonda[4], Gian Luca Baiocchi[5], Miklosh Bala[6], Zsolt J. Balogh[7], Maurizio Berardino[8], Walter L. Biffl[9], Pierre Bouzat[10], Andras Buki[11,12], Marco Ceresoli[13,14], Randall M. Chesnut[15], Osvaldo Chiara[16], Giuseppe Citerio[14,17], Federico Coccolini[3], Raul Coimbra[18], Salomone Di Saverio[19], Gustavo P. Fraga[20], Deepak Gupta[21], Raimund Helbok[22], Peter J. Hutchinson[23,24], Andrew W. Kirkpatrick[25], Takahiro Kinoshita[26], Yoram Kluger[27], Ari Leppaniemi[28], Andrew I. R. Maas[29], Ronald V. Maier[30], Francesco Minardi[1], Ernest E. Moore[31], John A. Myburgh[32], David O. Okonkwo[33], Yasuhiro Otomo[34], Sandro Rizoli[35], Andres M. Rubiano[36,37], Juan Sahuquillo[38],



Consensus Based - Flowchart:
Management of TBI in Absence of Neurological Surgery Services

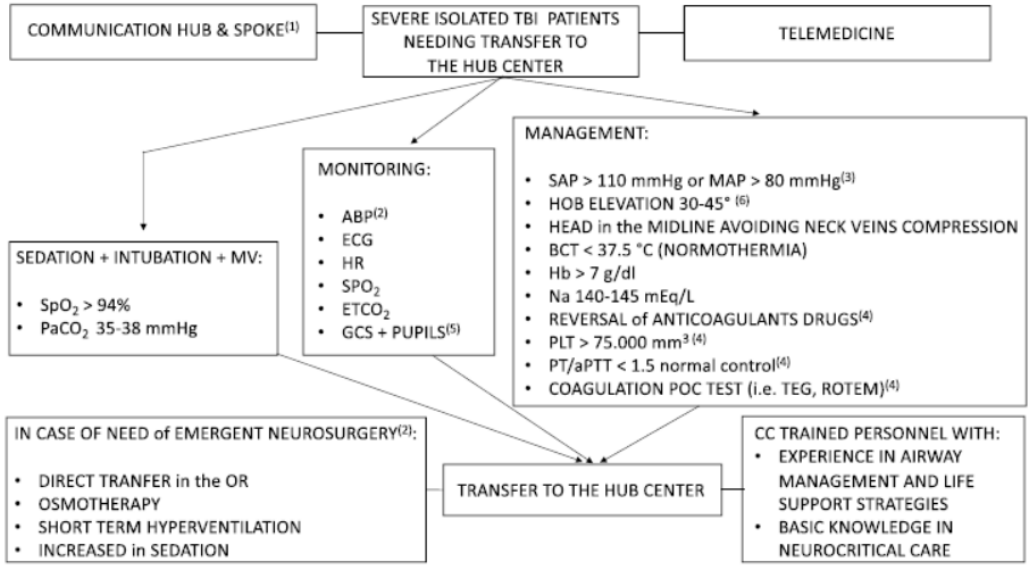
Picetti *et al.*
World Journal of Emergency Surgery 2023, **18**(1):5
https://doi.org/10.1186/s13017-022-00468-2

World Journal of Emergency Surgery

RESEARCH **Open Access**

Early management of isolated severe traumatic brain injury patients in a hospital without neurosurgical capabilities: a consensus and clinical recommendations of the World Society of Emergency Surgery (WSES)

Edoardo Picetti[1*], Fausto Catena[2], Fikri Abu-Zidan[3], Luca Ansaloni[4], Rocco A. Armonda[5,6], Miklosh Bala[7], Zsolt J. Balogh[8], Alessandro Bertuccio[9], Walt L. Biffl[10], Pierre Bouzat[11], Andras Buki[12], Davide Cerasti[13], Randall M. Chesnut[14,15,16], Giuseppe Citerio[17,18], Federico Coccolini[19], Raul Coimbra[20], Carlo Coniglio[21], Enrico Fainardi[22], Deepak Gupta[23], Jennifer M. Gurney[24,25], Gregory W. J. Hawryluk[26], Raimund Helbok[27], Peter J. A. Hutchinson[28], Corrado Iaccarino[29], Angelos Kolias[30,31], Ronald W. Maier[32], Matthew J. Martin[33], Geert Meyfroidt[34,35], David O. Okonkwo[36], Frank Rasulo[37], Sandro Rizoli[38], Andres Rubiano[39], Juan Sahuquillo[40], Valerie G. Sams[41], Franco Servadei[42,43], Deepak Sharma[44], Lori Shutter[45], Philip F. Stahel[46], Fabio S. Taccone[47], Andrew Udy[48], Tommaso Zoerle[49,50], Vanni Agnoletti[51], Francesca Bravi[52], Belinda De Simone[53], Yoram Kluger[54], Costanza Martino[55], Ernest E. Moore[56], Massimo Sartelli[57], Dieter Weber[58] and Chiara Robba[59,60]



Consensus Based Protocols:
TBI Care Guided by Clinical Exam and CT

Journal of Neurotrauma, VOL. 37, NO. 11 | Original Articles

normal

Consensus-Based Management Protocol (CREVICE Protocol) for the Treatment of Severe Traumatic Brain Injury Based on Imaging and Clinical Examination for Use When Intracranial Pressure Monitoring Is Not Employed

Randall M. Chesnut, Nancy Temkin, Walter Videtta, Gustavo Petroni, Silvia Lujan, Jim Pridgeon, Sureyya Dikmen, Kelley Chaddock, Jason Barber, Joan Machamer, Nahuel Guadagnoli, Peter Hendrickson, Sergio Aguilera, Victor Alanis, Manuel Enrique Bello Quezada, Ermitaño Bautista Coronel, Luis Alberto Bustamante, Armando C. Cacciatori, Carlos Javier Carricondo, ... See all authors

Published Online: 21 May 2020 | https://doi.org/10.1089/neu.2017.5599

- Unless clinically contraindicated, treatment for SICH should be started in the presence of ≥1 Major Criteria or ≥2 Minor Criteria:
- Major Criteria
  - CT classification of Marshall III or worse
    - Compressed cisterns (Marshall DI III)
    - Midline shift > 5 mm (Marshall DI IV)
      - Non-evacuated mass lesion >25 cc
  - Minor Criteria
    - Glasgow Coma Scale motor score ≤ 4
    - Pupillary asymmetry
    - Abnormal pupillary reactvity
    - Marshall DI II

Treatment may also be considered in other patients at the discretion of the treating physician

CT schedule
- Initial
  - Repeat at ≥ 12 hrs if initial done at ≤ 4 hrs
- 24 hrs
- 48 hrs
- PRN

Marshall Classification of most recent CT scan		GCS Motor and Pupils NP = Normal Pupils AP= Pupils Abnormal, without worsening since injury							
		GCS-M 6		GCS-M 5		GCS-M 4		GCS-M 1-3	
		NP	AP	NP	AP	NP	AP	NP	AP
During first 24 hours	DI 1-2								
	EML / DI 1-2								
	DI 3								
	EML / DI 3								
		NP	AP	NP	AP	NP	AP	NP	AP
After about 48 hours	DI 1-2								
	EML / DI 1-2								
	DI 3								
	EML / DI 3								
		NP	AP	NP	AP	NP	AP	NP	AP
After about 72 hours	DI 1-2								
	EML / DI 1-2								
	DI 3								
	EML / DI 3								
		NP	AP	NP	AP	NP	AP	NP	AP
After 72 hours	DI 1-2								
	EML / DI 1-2								
	DI 3								
	EML / DI 3								

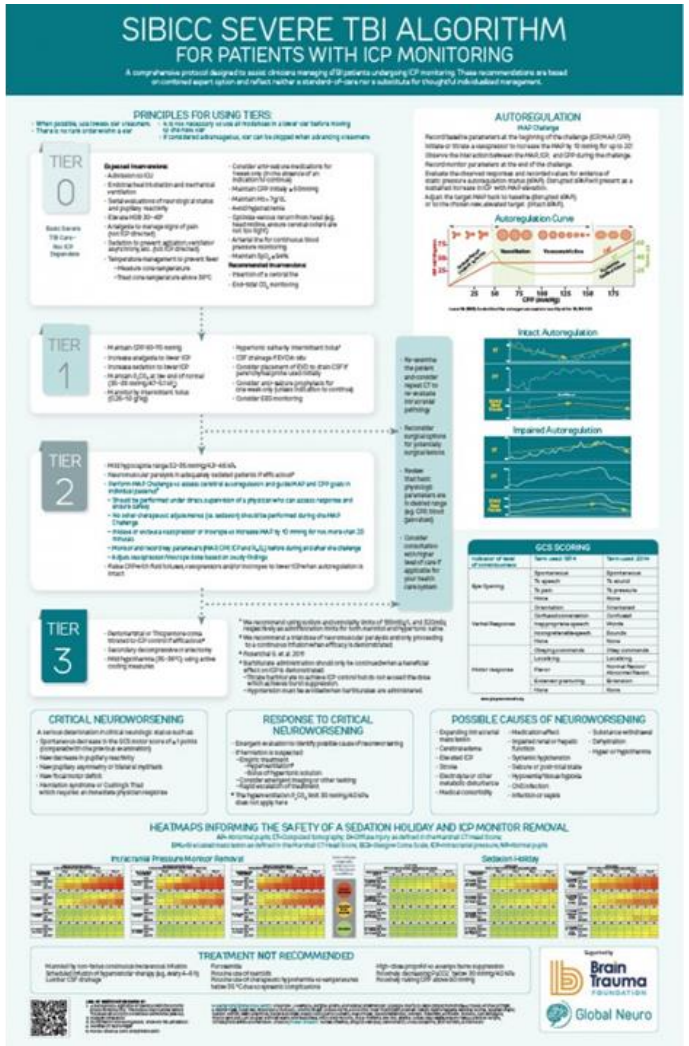
CONSENSUS Based Algorithm: TBI Care Guided by Clinical Exam, CT and Invasive ICP Monitoring

Intensive Care Med (2019) 45:1783–1794
https://doi.org/10.1007/s00134-019-05805-9

CONFERENCE REPORTS AND EXPERT PANEL

A management algorithm for patients with intracranial pressure monitoring: the Seattle International Severe Traumatic Brain Injury Consensus Conference (SIBICC)

Gregory W. J. Hawryluk[1], Sergio Aguilera[2,3], Andras Buki[4,5], Eileen Bulger[6], Giuseppe Citerio[7,8], D. Jamie Cooper[9,10], Ramon Diaz Arrastia[11], Michael Diringer[12,13], Anthony Figaji[14], Guoyi Gao[15], Romergryko Geocadin[16], Jamshid Ghajar[17], Odette Harris[18], Alan Hoffer[19], Peter Hutchinson[20], Mathew Joseph[21], Ryan Kitagawa[22], Geoffrey Manley[23], Stephan Mayer[24], David K. Menon[25], Geert Meyfroidt[26], Daniel B. Michael[27], Mauro Oddo[28], David Okonkwo[29], Mayur Patel[30], Claudia Robertson[31], Jeffrey V. Rosenfeld[32,33], Andres M. Rubiano[34,35], Juan Sahuquillo[36], Franco Servadei[37], Lori Shutter[38], Deborah Stein[39], Nino Stocchetti[40,41], Fabio Silvio Taccone[42], Shelly Timmons[43], Eve Tsai[44], Jamie S. Ullman[45], Paul Vespa[46,47,48,49], Walter Videtta[50], David W. Wright[51], Christopher Zammit[52] and Randall M. Chesnut[53,54,55,56]*



CONSENSUS Based Algorithm:
TBI Care Guided by Clinical Exam, CT and Invasive ICP Monitoring + Invasive Brain O2 Monitoring

Intensive Care Med
https://doi.org/10.1007/s00134-019-05900-x

CONFERENCE REPORTS AND EXPERT PANEL

A management algorithm for adult patients with both brain oxygen and intracranial pressure monitoring: the Seattle International Severe Traumatic Brain Injury Consensus Conference (SIBICC)

Randall Chesnut[1,2], Sergio Aguilera[3,4], Andras Buki[5,6], Eileen Bulger[7], Giuseppe Citerio[8,9], D. Jamie Cooper[10,11], Ramon Diaz Arrastia[12], Michael Diringer[13], Anthony Figaji[14], Guoyi Gao[15], Romer Geocadin[16], Jamshid Ghajar[17], Odette Harris[18], Alan Hoffer[19], Peter Hutchinson[20], Mathew Joseph[21], Ryan Kitagawa[22], Geoffrey Manley[23], Stephan Mayer[24], David K. Menon[25], Geert Meyfroidt[26], Daniel B. Michael[27], Mauro Oddo[28], David Okonkwo[29], Mayur Patel[30], Claudia Robertson[31], Jeffrey V. Rosenfeld[32,33], Andres M. Rubiano[34,35], Juan Sahuquillo[36], Franco Servadei[37,38], Lori Shutter[39], Deborah Stein[40], Nino Stocchetti[41,42], Fabio Silvio Taccone[43], Shelly Timmons[44], Eve Tsai[45], Jamie S. Ullman[46], Paul Vespa[47], Walter Videtta[48], David W. Wright[49], Christopher Zammit[50] and Gregory W. J. Hawryluk[51]*

Abstract

Background: Current guidelines for the treatment of adult severe traumatic brain injury (sTBI) consist of high-quality evidence reports, but they are no longer accompanied by management protocols, as these require expert opinion to bridge the gap between published evidence and patient care. We aimed to establish a modern sTBI protocol for adult patients with both intracranial pressure (ICP) and brain oxygen monitors in place.

Methods: Our consensus working group consisted of 42 experienced and actively practicing sTBI opinion leaders from six continents. Having previously established a protocol for the treatment of patients with ICP monitoring alone, we addressed patients who have a brain oxygen monitor in addition to an ICP monitor. The management protocols were developed through a Delphi-method-based consensus approach and were finalized at an in-person meeting.

Results: We established three distinct treatment protocols, each with three tiers whereby higher tiers involve therapies with higher risk. One protocol addresses the management of ICP elevation when brain oxygenation is normal. A second addresses management of brain hypoxia with normal ICP. The third protocol addresses the situation when both intracranial hypertension and brain hypoxia are present. The panel considered issues pertaining to blood transfusion and ventilator management when designing the different algorithms.

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Full author information is available at the end of the article

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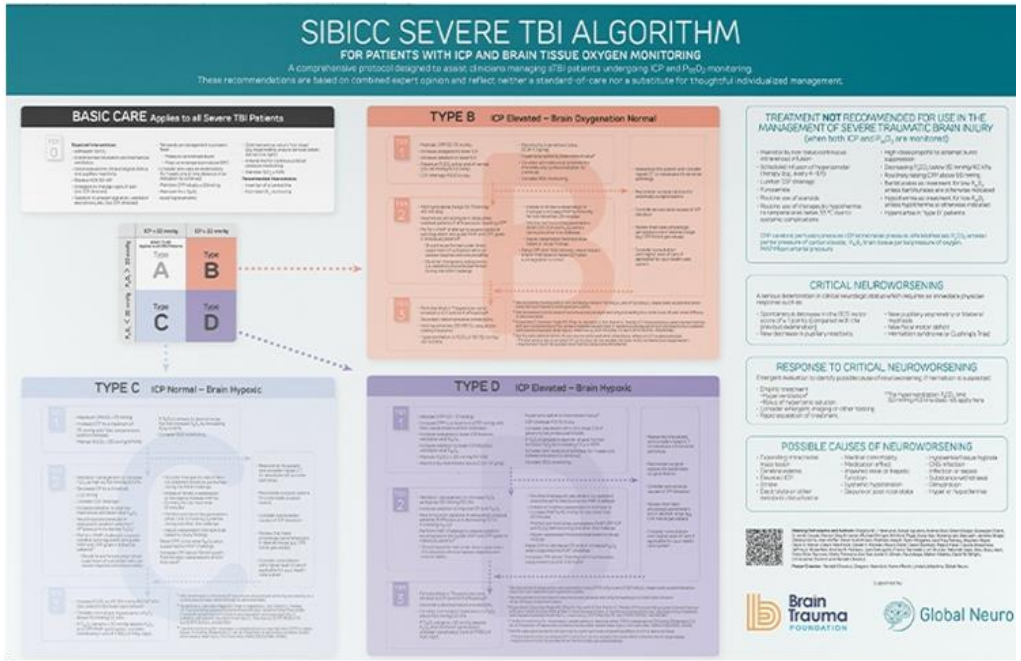
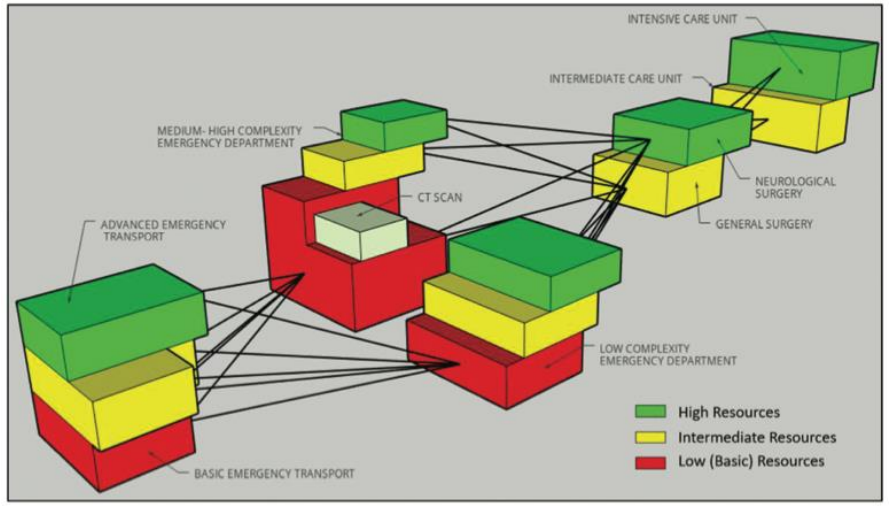


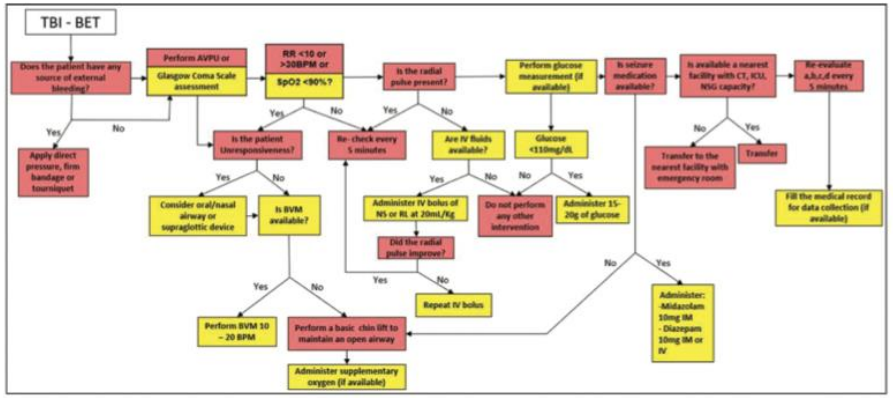
Consensus Based Protocols: BOOTStrap
Stratified Protocols for TBI Care at EMS/ER/OR and ICU

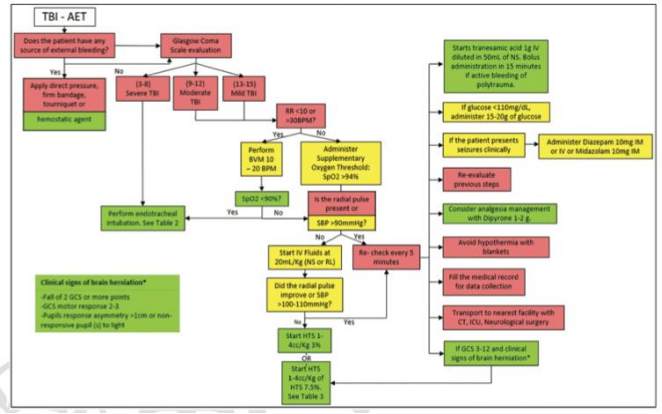
THIEME OPEN ACCESS J Neurosci Rural Pract 2020;11:7–22 Position Paper

Recommendations of the Colombian Consensus Committee for the Management of Traumatic Brain Injury in Prehospital, Emergency Department, Surgery, and Intensive Care (Beyond One Option for Treatment of Traumatic Brain Injury: A Stratified Protocol [BOOTStraP])

Andres M. Rubiano[1] David S. Vera[2] Jorge H. Montenegro[3] Nancy Carney[4] Angelica Clavijo[5] Jose N. Carreño[6] Oscar Gutierrez[7] Jorge Mejia[8] Juan D. Ciro[9] Ninel D. Barrios[10] Alvaro R. Soto[11] Paola A. Tejada[12] Maria C. Zerpa[13] Alejandro Gomez[14] Norberto Navarrete[15] Oscar Echeverry[16] Mauricio Umaña[17] Claudia M. Restrepo[18] Jose L. Castillo[19] Oscar A. Sanabria[20] Maria P. Bravo[21] Claudia M. Gomez[22] Daniel A. Godoy[23] German D. Orjuela[24] Augusto A. Arias[25] Raul A. Echeverri[26] Jorge Paranos[27]



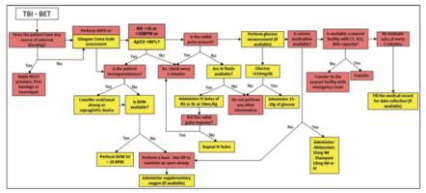


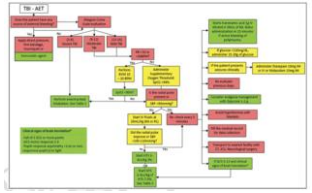


Algorithm 7 (Management algorithm of a patient who requires immediate surgery in a medical center that does it not have neurosurgery)

Algorithm 8 (Management algorithm of a patient who requires immediate surgery in a medical center that does it have neurosurgery but not ICU)

Algorithm 9 (Management algorithm of a patient with moderate-severe TBI in an intermediate care unit)





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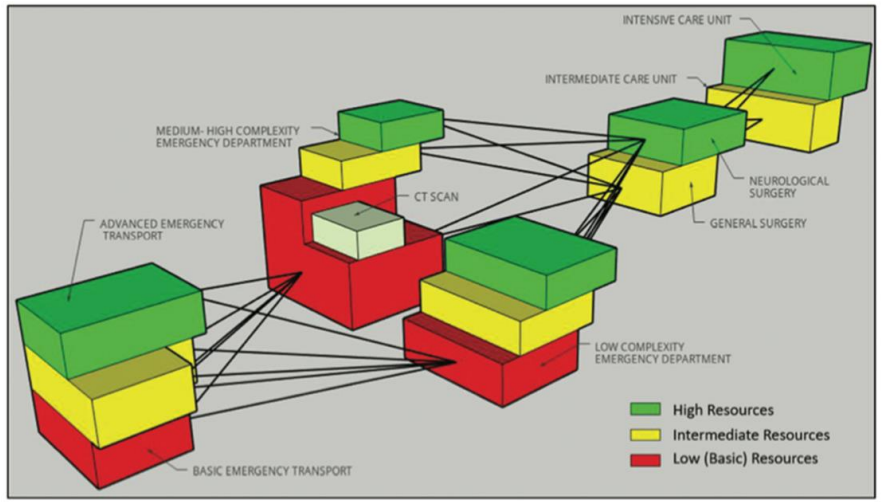

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Position Paper

Recommendations of the Colombian Consensus Committee for the Management of Traumatic Brain Injury in Prehospital, Emergency Department, Surgery, and Intensive Care (Beyond One Option for Treatment of Traumatic Brain Injury: A Stratified Protocol [BOOTStraP])

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› Author Affiliations

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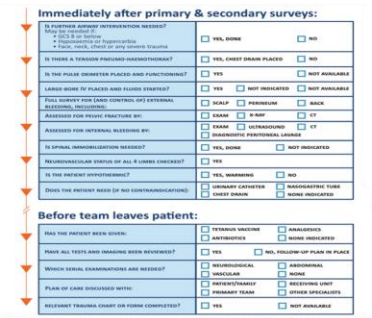


ABC

Systolic Blood pressure	Present	1
	>90 mm Hg	0
	<=90 mmHg	1
Heart rate	< 120	0
	>= 120	1
FAST	Negative	0
	Positive	1

Table 5 Suggestions for vasopressor therapy preparation

Medication		
Vasopressor therapy	Noradrenaline	Adrenaline
	Amp × 4 mg/4 mL	Amp × 1 mg/mL
	Dose: 0.05–0.5 µg/kg/min	Dose: 0.1–2 µg/kg/min

Table 3 Suggestions for HTS preparation

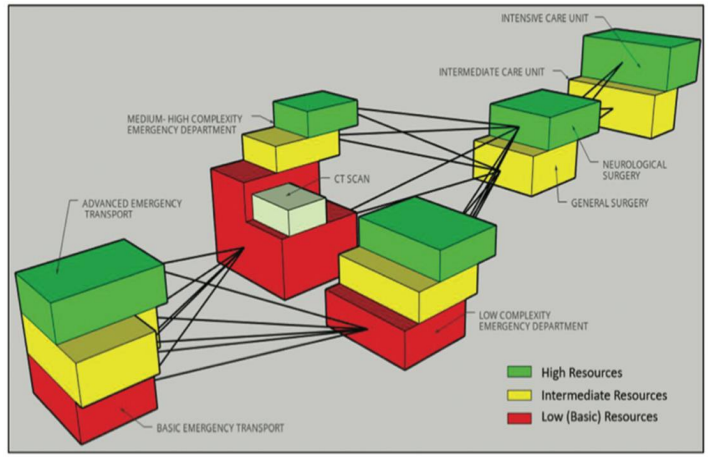
Hypertonic fluids	HTS 3% Peripheral vein	HTS 7.5% Peripheral vein
	NS (0.9%) 400 mL + sodium chloride ampoules 100 mL (ampoules of 20 mEq in 10 mL)	NS (0.9%) 100 mL + sodium chloride ampoules 150 mL (ampoules of 20 mEq in 10 mL)
	Dose: 3–4 mL/kg For a patient of 70 kg = 210–280 mL per dose Only for use if SBP < 100 mm Hg or clinical signs of brain herniation	Dose: 2 mL/kg For a patient of 70 kg = 140 mL per dose Only for use if SBP < 100 mm Hg or clinical signs of brain herniation

Abbreviations: HTS, hypertonic saline; NS, normal saline; SBP, systolic blood pressure.

Table 6 Surgical indications for immediate transfer to a higher level facility with neurosurgery capabilities

Clinical criteria	Imaging criteria
Pupillary asymmetry with 1 mm of difference	Midline shift > 5 mm
GCS motor response of 4 or less	Total cisterns compression (Grade III)
	Epidural hematoma ≥ 30 mL in volume
	Intracerebral hematoma ≥ 50 mL in volume
	Subdural hematoma > 10 mm in width
	Posterior fossa hematoma with hydrocephalus

Abbreviation: GCS, Glasgow coma scale.
Note: One clinical criterion + one imaging criterion = surgical indication.
One isolated clinical criterion = medical management.
One isolated imaging criterion = medical management.



Algoritmo 8 (Algoritmo de manejo de un paciente que requiere cirugía inmediata en un entro médico que no dispone de neurocirugía pero si de UCI)

a. Controlar las fuentes externas de hemorragia mediante presión directa, vendaje firme, agente hemostático o torniquete.
b. Evaluación de la GCS
   i. Leve (GCS 13-15)
   ii. Moderado (GCS 9-12)
   iii. Grave (GCS 3-8)
c. Evaluar la frecuencia respiratoria (FR) clínicamente y realizar la medición de SpO2.
   i. Administrar oxígeno suplementario. Umbral: SpO2 >94%
   ii. Si la FR es <10 o >30RPM realice la DBM con una FR entre 10-20 RPM y prepárese para la intubación orotraqueal.
   iii. Si después de la DBM y la FR entre 10-20 RPM, el paciente sigue sin responder, y la SpO2 <90%, realice la intubación orotraqueal. Véase la medicación en **la Tabla 2.**
   iv. Si la IET falla, realice el manejo de la vía aérea con un dispositivo supraglótico. Inicie la ventilación una vez en posición.
   v. Solicitar ABG para definir las variaciones de FiO2. Umbral PaO2 >50mmHg/PCo2 30-35mmHg.
   vi. Iniciar la ventilación mecánica con una FR entre 10-20RPM con volúmenes tidales bajos (5-7mL/Kg).
d. Confirmar la presencia del pulso radial y la medición no invasiva de la PAS.
   i. Si está presente, vuelva a comprobarlo cada 5 minutos
   ii. Si no está presente, inicie fluidos IV a 20mL/Kg (SSN o LR), compruebe la mejora del pulso radial y la PAS >100-110mmHg.
   iii. Si no hay una mejora en la PAS, comience con solución salina hipertónica 1-4cc/Kg de solución salina hipertónica 7,5% o 3%. Véase la preparación de solución salina hipertónica en **la Tabla 3.**
   iv. Si hay hemorragia activa o politraumatismo se inicia ácido tranexámico 1g/Kg IV diluido en 50mL de SSN. Administración del bolo en 15 minutos.
   v. Identificar clínicamente otras fuentes de shock (NT, taponamiento cardíaco, hemorragia abdominal, hemorragia pélvica).
   vi. Si se sospecha de neumotórax a tensión (disnea progresiva, ausencia de ruidos respiratorios y ausencia de pulso radial: descomprimir con una aguja).

Confirmar las lesiones sospechosas con una radiografía de tórax, una ecografía de traumatismo o un TAC. Realice un TAC craneal.
Evaluar la radiografía cervical o el TAC cervical para descartar fracturas cervicales.

i. Si no hay lesiones, retire el collarín.

Requiere la consulta de cirugía general, ortopedia y/o neurocirugía.

Si se identifica una fractura pélvica (clínica o radiológica) poner una faja pélvica o una faja de hoja.
Si no hay una mejora de la PAS después de los pasos anteriores, iniciar vasopresores con noradrenalina o adrenalina a las dosis presentadas en **la Tabla 5.**
Comprobar las necesidades de transfusión sanguínea temprana en una proporción de 1:1:1 de GR, plasma y plaquetas. Los exámenes sugeridos para las decisiones incluyen Lactato >2,5mg/dL y EB > -6. Utilizar las puntuaciones TASH o ABC para las indicaciones de transfusión (ver Apéndice B).
Mantener un gasto urinario superior a 50cc/h.

Solicitar niveles de hemoglobina. Umbral >9 g/dL.

Medir los niveles de glucosa. Administrar 15-20g de glucosa si el nivel de glucosa es <110mg/dL, re comprobar los valores para mantener un umbral de 110-170mg/dL.
Reevaluar el GCS.

i. Si GCS 3-12 y signos clínicos de hernia cerebral (caída de GCS de 2 puntos, asimetría de la respuesta de las pupilas >1cm o pupilas que no responden a la luz, respuesta motora anormal con GCS motor 2-3) iniciar solución salina hipertónica 3% o 7,5% como se prepara en **la Tabla 3**.
ii. En pacientes con PAS >110mmHg, una segunda opción es el Manitol 1g/Kg en sustitución del solución salina hipertónica.
iii. La terapia hiperosmolar con solución salina hipertónica o Manitol puede repetirse cada 4 o 6 horas.
iv. Medir el sodio sérico. Umbral 135-145mEq/L.

vii. Solicite la monitorización de la PCI (opcional). Umbral 20-25mmHg o 28cm de H2O. Drenaje de LCR si ventriculostomía como medida terapéutica para mantener los umbrales.
viii. Mantener una PPC entre 60-70mmHg con variaciones según los requerimientos metabólicos.
ix. Realice una ecografía del nervio óptico (ONUS) o una pupilometría (PPM) (si está disponible) para ver las tendencias que siguen al paciente bajo sedación. Umbrales: ONUS(<5,2mm) / PPM: NPi >3
x. Evaluar con neurocirugía la descompresión craneal primaria como terapia de control de daños si hay edema cerebral o desplazamiento de la línea media en la primera TC.

xi. Realizar una exploración neurológica horaria si el paciente permanece en el quirófano (OR) a la espera de ser trasladado a una UCI externa.
xii. Realizar nuevo TAC si hay signos clínicos de hernia cerebral tras la neurocirugía. Los tiempos sugeridos incluyen 24 horas después de la cirugía o temprano si el paciente se deteriora clínicamente.

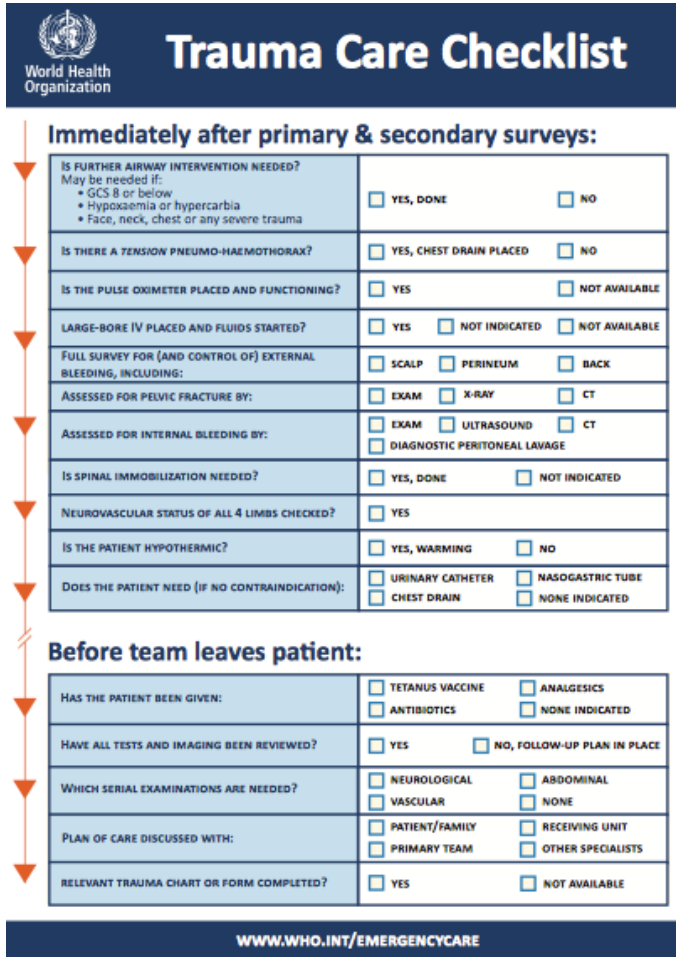
q. Evaluar clínicamente las convulsiones
   i. Si hay alguna convulsión, administrar Diazepam 10mg IM o IV o Midazolam 10mg IM.
   ii. Si hay convulsiones, tras el uso de BZD, comenzar con fenitoína 15-20mg/Kg diluida en SSN o Dextrosa al 5%.
   iii. Vuelva a evaluar los pasos **c**, **d**, **e y f**.

r. Reevaluar **a, b, c, d, e, f** cada 15 minutos.
s. Considerar el manejo de la analgesia con Dipirona 1-2 g.
t. Iniciar la sedación con Midazolam y Fentanilo a dosis estándar de 0,03 - 0,5 mg/Kg/h y 1-2 mcg/Kg/h.
u. Evite la hipotermia con mantas.
v. Rellenar la historia clínica para la recogida de datos.
w. Realice la lista de comprobación de la atención traumatológica de la OMS **(Tabla 6)**
x. Transporte a un nivel de atención superior con capacidad de UCI lo antes posible

Care Pathways: What do we have until now?

- Evidence/Consensus Based Guidelines in Different Countries with Different Questions and Different Resources
- Expert Consensus for Specific Topics (Ex.: Craniectomy / Cranioplasty)
- 1 Protocol for Managing Patients with CT and Clinical Examination
- 1 Consensus for Managing Patients with Polytrauma and TBI
- 1 Consensus for Managing Patients with Severe TBI without NQX Service
- 1 Consensus Algorithm for Managing Patients with ICP
- 1 Consensus Algorithm to Manage Patients with ICP/PTiO2
- 1 Consensus Based Set of Protocols for Different Levels of Care and Resources

What is Missing?



World Health Organization

Trauma Care Checklist

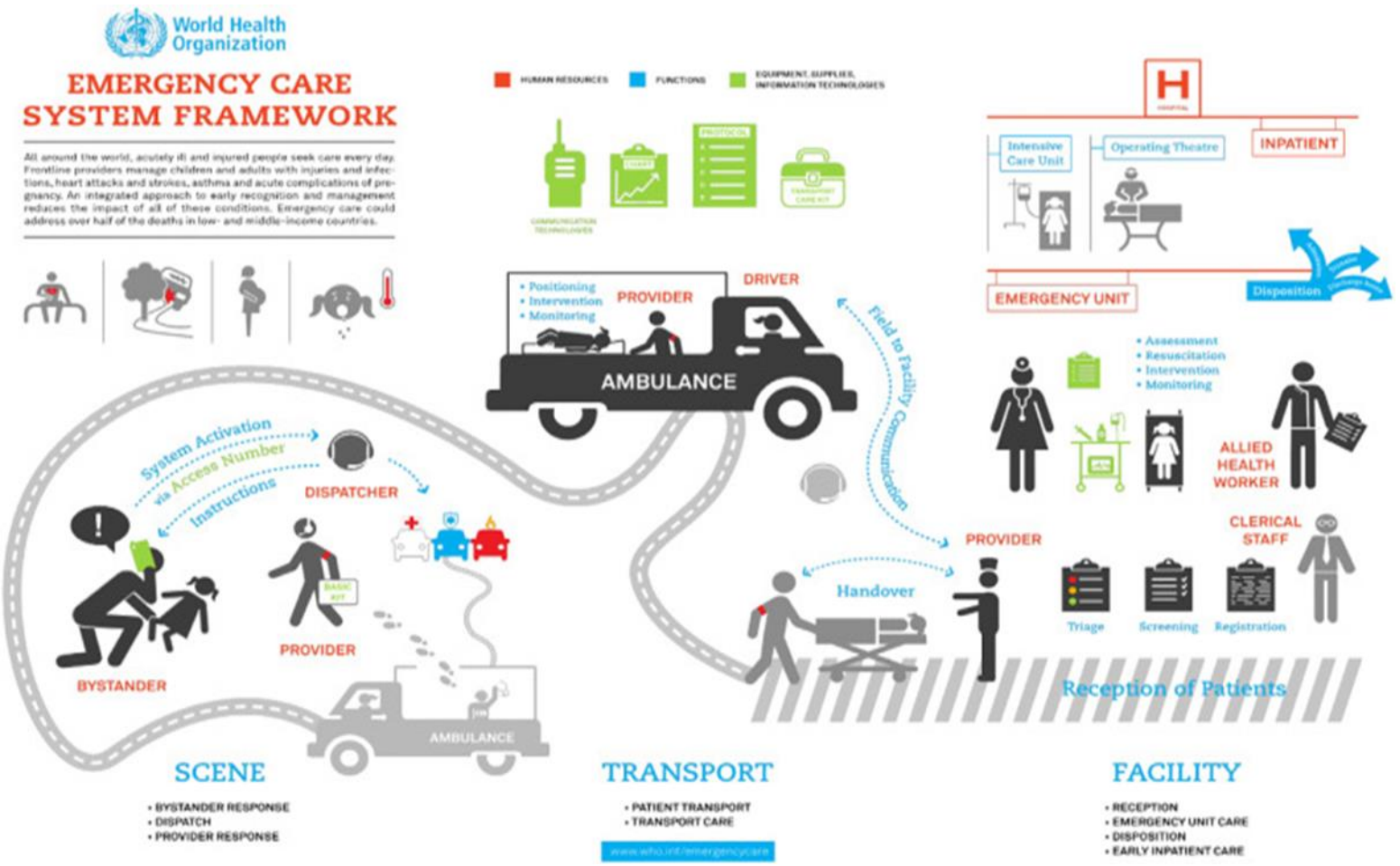
Immediately after primary & secondary surveys:

IS FURTHER AIRWAY INTERVENTION NEEDED? May be needed if: • GCS 8 or below • Hypoxaemia or hypercarbia • Face, neck, chest or any severe trauma	☐ YES, DONE ☐ NO
IS THERE A *TENSION* PNEUMO-HAEMOTHORAX?	☐ YES, CHEST DRAIN PLACED ☐ NO
IS THE PULSE OXIMETER PLACED AND FUNCTIONING?	☐ YES ☐ NOT AVAILABLE
LARGE-BORE IV PLACED AND FLUIDS STARTED?	☐ YES ☐ NOT INDICATED ☐ NOT AVAILABLE
FULL SURVEY FOR (AND CONTROL OF) EXTERNAL BLEEDING, INCLUDING:	☐ SCALP ☐ PERINEUM ☐ BACK
ASSESSED FOR PELVIC FRACTURE BY:	☐ EXAM ☐ X-RAY ☐ CT
ASSESSED FOR INTERNAL BLEEDING BY:	☐ EXAM ☐ ULTRASOUND ☐ CT ☐ DIAGNOSTIC PERITONEAL LAVAGE
IS SPINAL IMMOBILIZATION NEEDED?	☐ YES, DONE ☐ NOT INDICATED
NEUROVASCULAR STATUS OF ALL 4 LIMBS CHECKED?	☐ YES
IS THE PATIENT HYPOTHERMIC?	☐ YES, WARMING ☐ NO
DOES THE PATIENT NEED (IF NO CONTRAINDICATION):	☐ URINARY CATHETER ☐ NASOGASTRIC TUBE ☐ CHEST DRAIN ☐ NONE INDICATED

Before team leaves patient:

HAS THE PATIENT BEEN GIVEN:	☐ TETANUS VACCINE ☐ ANALGESICS ☐ ANTIBIOTICS ☐ NONE INDICATED
HAVE ALL TESTS AND IMAGING BEEN REVIEWED?	☐ YES ☐ NO, FOLLOW-UP PLAN IN PLACE
WHICH SERIAL EXAMINATIONS ARE NEEDED?	☐ NEUROLOGICAL ☐ ABDOMINAL ☐ VASCULAR ☐ NONE
PLAN OF CARE DISCUSSED WITH:	☐ PATIENT/FAMILY ☐ RECEIVING UNIT ☐ PRIMARY TEAM ☐ OTHER SPECIALISTS
RELEVANT TRAUMA CHART OR FORM COMPLETED?	☐ YES ☐ NOT AVAILABLE

WWW.WHO.INT/EMERGENCYCARE



Traumatic brain injury: progress and challenges in prevention, clinical care, and research

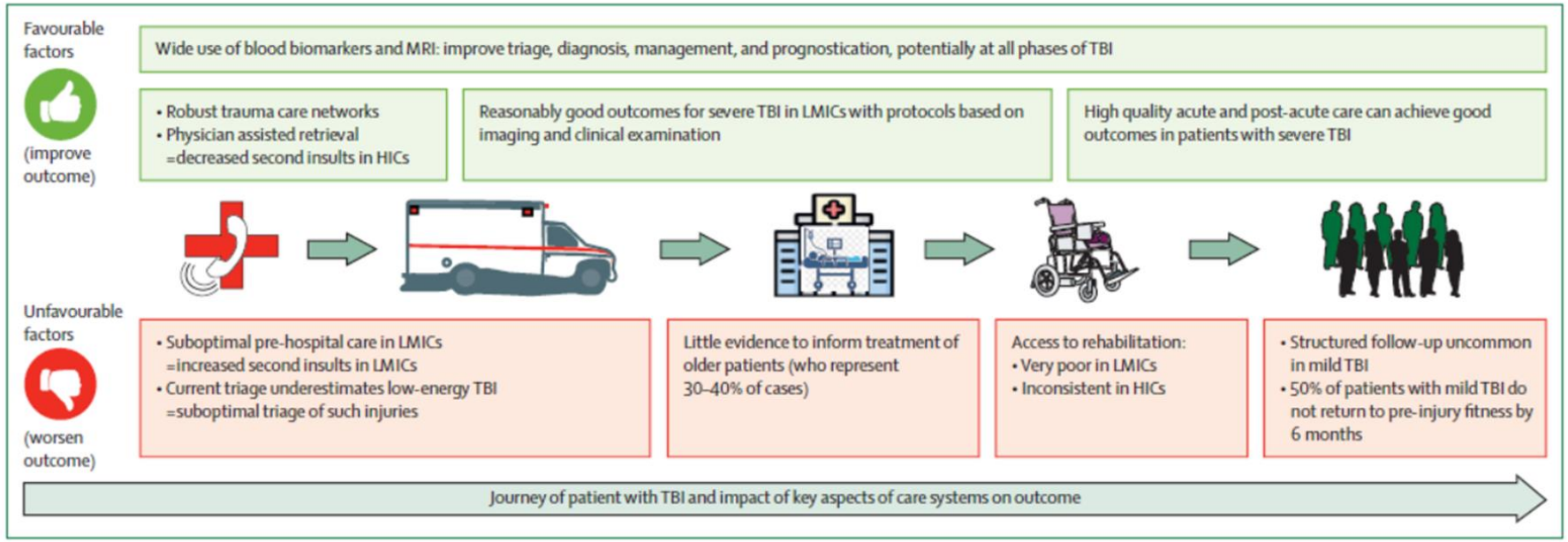


Figure 4: **Advances and remaining challenges in the provision of health care for people with traumatic brain injury along the trauma chain**
Continuity of care along the chain of trauma health care is of paramount importance to achieve good outcomes. If pre-hospital care is inadequate, secondary damage might be so severe that outcome will be poor, no matter how good the in-hospital treatment might be. Conversely, benefits accrued from excellent in-hospital treatment might be lost if they are not consolidated by good post-acute care. Note that many challenges relate to transitions across the links of the trauma chain. TBI=traumatic brain injury. HICs=high-income countries. LMICs=low-income and middle-income countries.

Integration of Innovation for Different Levels of Contexts and Resources

BRAIN INJURY
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Management of severe traumatic brain injury in regions with limited resources

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ABSTRACT

Importance: Severe traumatic brain injury (sTBI) is a critical health problem in regions of limited resources (RLRs). Younger populations are among the most impacted. The objective of this review is to analyze recent consensus-based algorithms, protocols and guidelines proposed for the care of patients with TBI in RLRs.

Observations: The principal mechanisms for sTBI in RLRs are road traffic injuries (RTIs) and violence. Limitations of care include suboptimal or non-existent pre-hospital care, overburdened emergency services, lack of trained human resources, and surgical and intensive care. Low-cost neuromonitoring systems are currently in testing, and formal neurotrauma registries are forming to evaluate both long-term outcomes and best practices at every level of care from hospital transport to the emergency department (ED), to the operating room and intensive care unit (ICU).

Conclusions and Relevance: The burden of sTBI is highest in RLRs. As working-age adults are the predominantly affected age-group, an increase in disability-adjusted life years (DALYs) generates a loss of economic growth in regions where economic growth is needed most. Four multi-institutional collaborations between high-income countries (HICs) and LMICs have developed evidence and consensus-based documents focused on capacity building for sTBI care as a means of addressing this substantial burden of disease.

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KEYWORDS
TRAUMATIC brain injury; LMICs; protocols; guidelines; neurotrauma

Innovation for Decision Making

BOX 392.1 Indications for Transfer to Centers With Neurosurgery and Neuroimaging Services

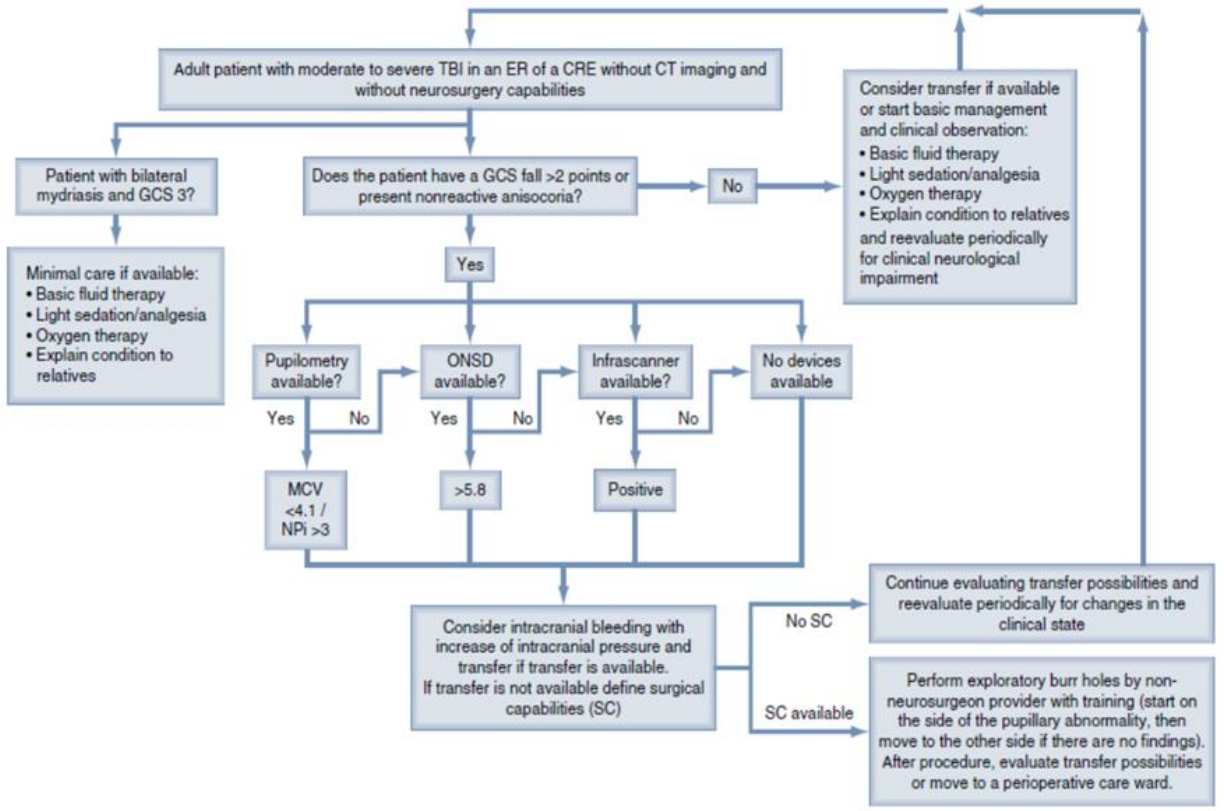
It is recommended that patients with moderate to severe TBI (GCS 3–12) be transferred immediately to hospitals with a high level of care with access to neuroimaging and neurosurgery.

It is recommended that patients with mild TBI (GCS 13–15) who meet one or more of the following criteria be referred for evaluation at an institution that has access to neuroimaging and neurosurgery:

- GCS under 15 up to 2 hours after injury
- Severe headache
- More than two episodes of vomiting
- Skull fracture, including depressed fractures or clinical signs of fracture of the skull base (raccoon eyes, retroauricular ecchymosis, otorrhea, or rhinorrhea)
- Age older than or equal to 60 years
- Blurred vision or diplopia
- Posttraumatic seizure
- Focal neurological deficit
- Previous craniotomy
- Fall of more than 1.5 m
- Retrograde amnesia more than 30 minutes and/or anterograde amnesia
- Suspected intoxication with alcohol and/or psychoactive substances

It is recommended that patients with mild TBI and who are in active treatment with anticoagulants, have active coagulopathies, or are pregnant be transferred to centers with neurosurgery and neuroimaging services.

GCS, Glasgow Coma Scale; *TBI*, traumatic brain injury.



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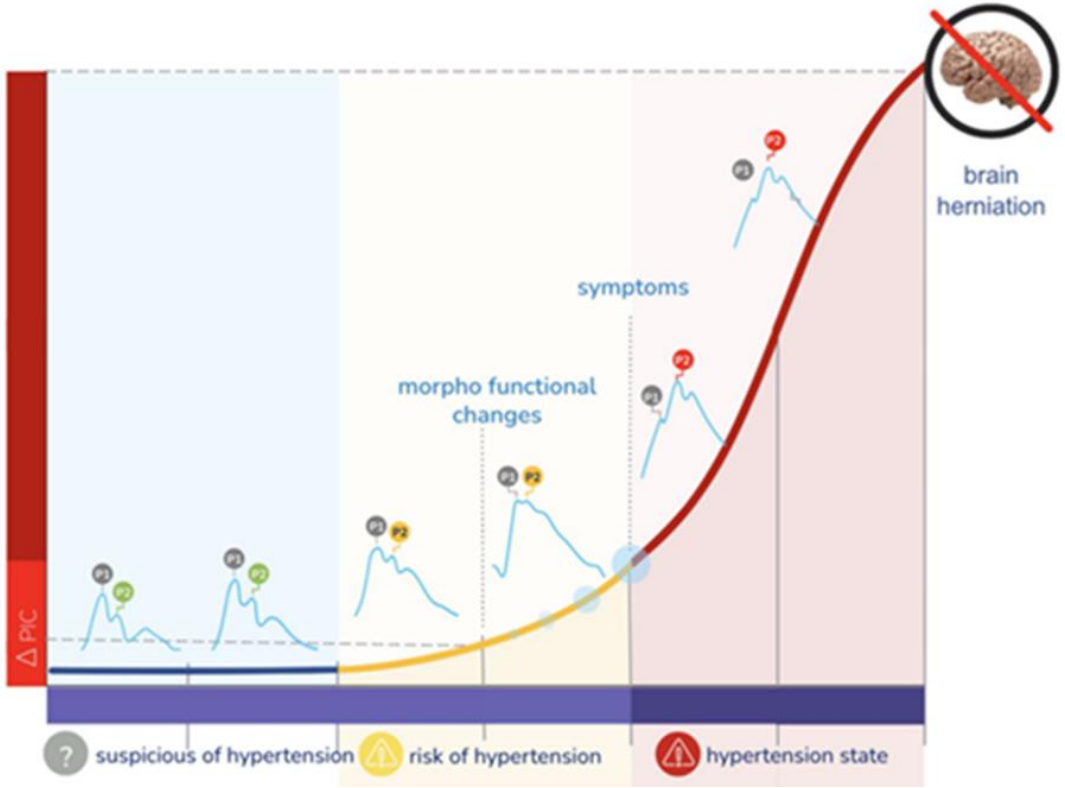
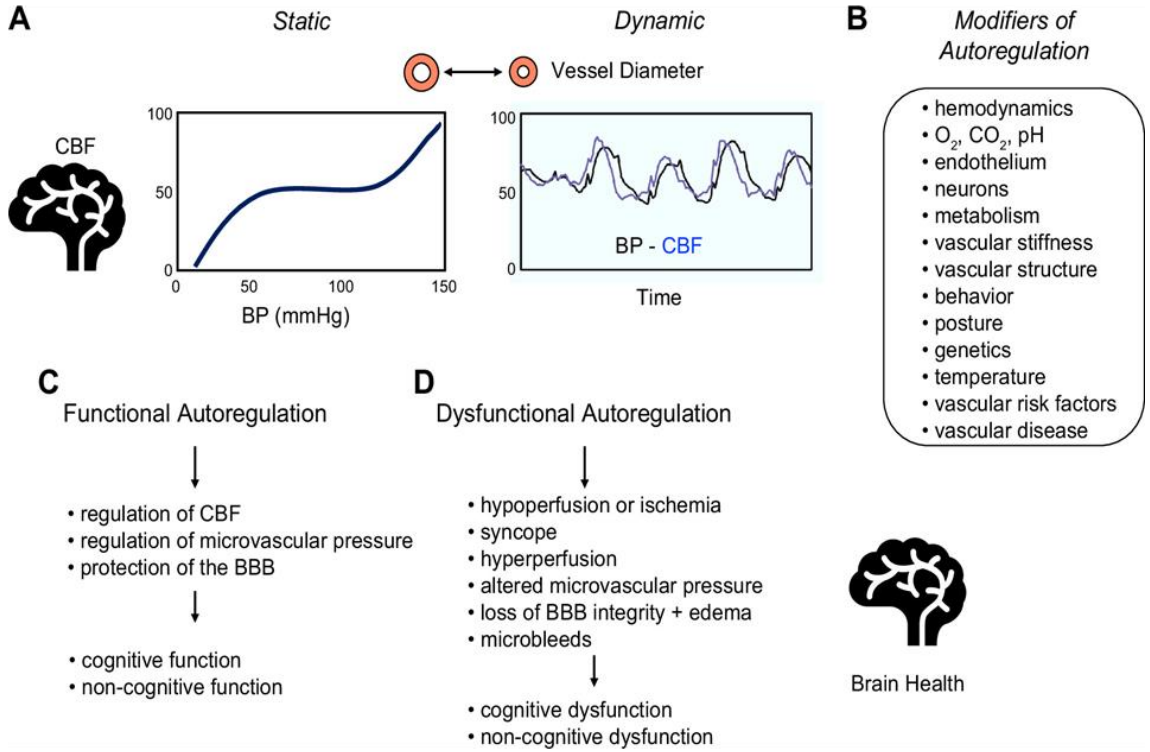
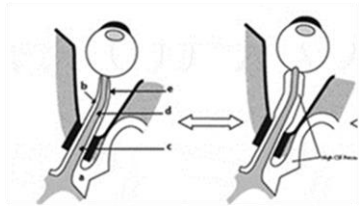
Compliance and Autoregulation Based Care







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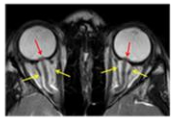

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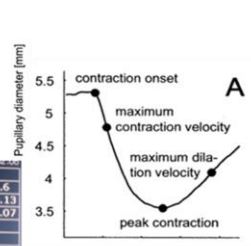
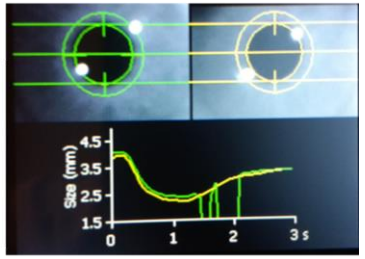
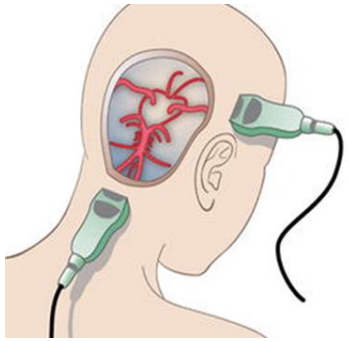
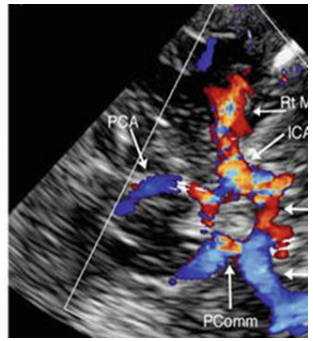








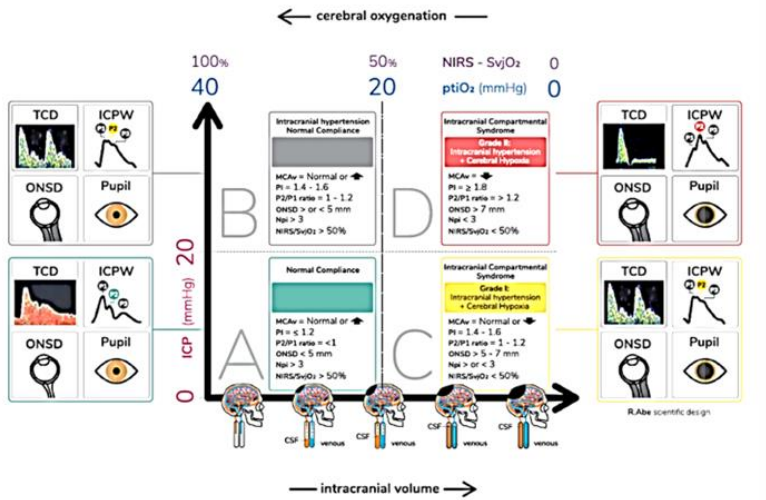
Godoy et al. Critical Care (2023) 27:137
https://doi.org/10.1186/s13054-023-04427-4

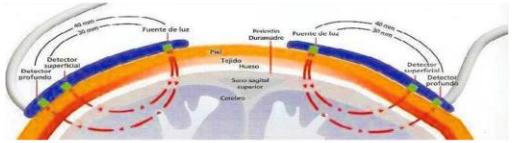
Critical Care

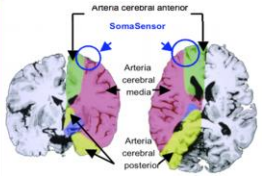
PERSPECTIVE Open Access

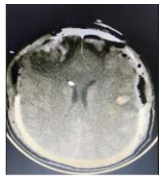
The intracranial compartmental syndrome: a proposed model for acute brain injury monitoring and management

Daniel Agustín Godoy[1], Sérgio Brasil[2*], Corrado Iaccarino[3,4,5], Wellingson Paiva[2] and Andres M. Rubiano[6,7]









REVIEW

Intracranial pressure management: moving beyond guidelines

Andres M. Rubiano[a], Anthony Figaji[b], and Gregory W. Hawryluk[c]

Purpose of review
The aim of this study was to provide an overview on advances in intracranial pressure (ICP) protocols for care, moving from traditional to more recent concepts.

Recent findings
Deep understanding of mechanics and dynamics of fluids and solids have been introduced for intracranial physiology. The amplitude or the harmonics of the cerebral-spinal fluid and the cerebral blood waves shows more information about ICP than just a numeric threshold. When the ICP overcome the compensatory mechanisms that maintain the compliance within the skull, an intracranial compartment syndrome (ICCS) is defined. Autoregulation monitoring emerge as critical tool to recognize CPP management. Measurement of brain tissue oxygen will be a critical intervention for diagnosing an ICCS. Surgical procedures focused on increasing the physiological compliance and increasing the volume of the compartments of the skull.

Summary
ICP management is a complex task, moving far than numeric thresholds for activation of interventions. The interactions of intracranial elements requires new interpretations moving beyond classical theories. Most of the traditional clinical studies supporting ICP management are not generating high class evidence. Recommendations for ICP management requires better designed clinical studies using new concepts to generate interventions according to the new era of personalized medicine.

Keywords
evidence-based guidelines, intracranial compartment syndrome, intracranial pressure, neuromonitoring, personalized medicine

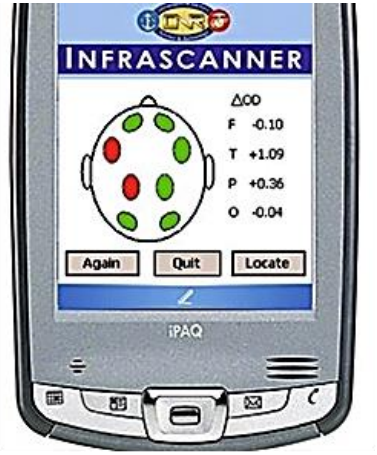
ELSEVIER

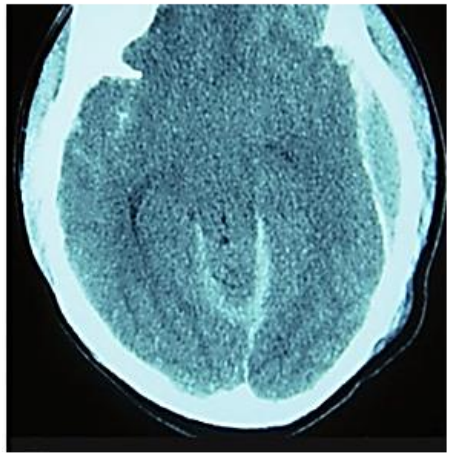
Journal of Critical Care
Volume 75, June 2023, 154260

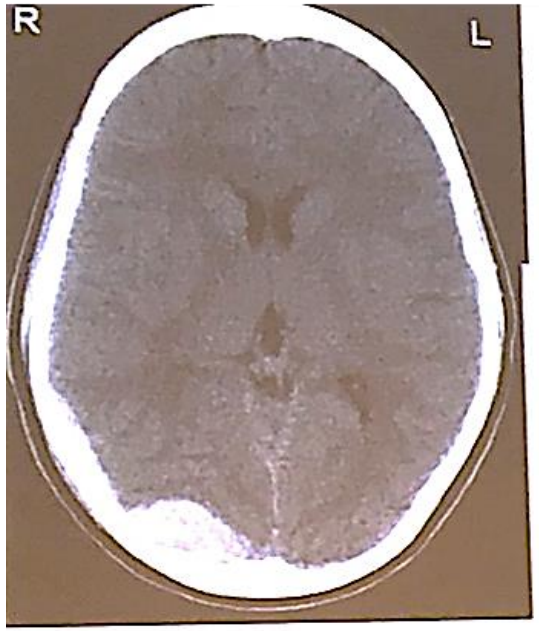
Avoiding brain hypoxia in severe traumatic brain injury in settings with limited resources - A pathophysiological guide

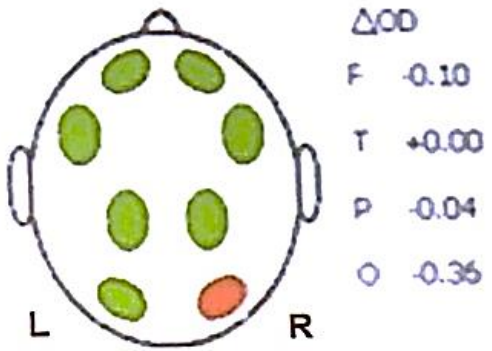
Daniel Agustin Godoy[a], Andres M. Rubiano[b c], Jorge Paranhos[d], Chiara Robba[e], Christos Lazaridis[f]

Innovation on Bleeding Detection and Compliance Evaluation









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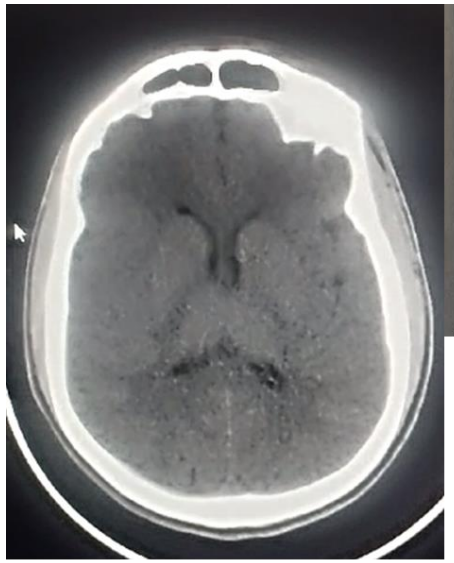
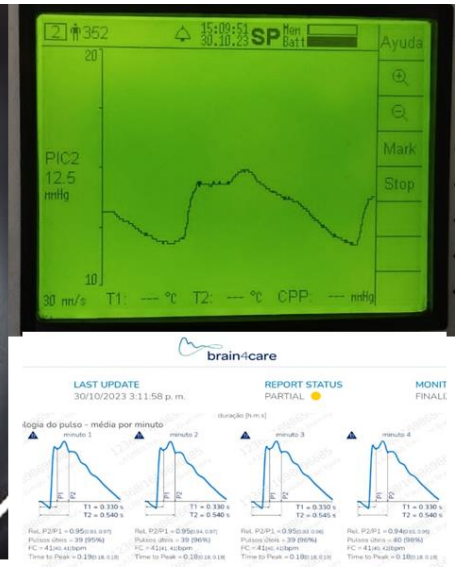
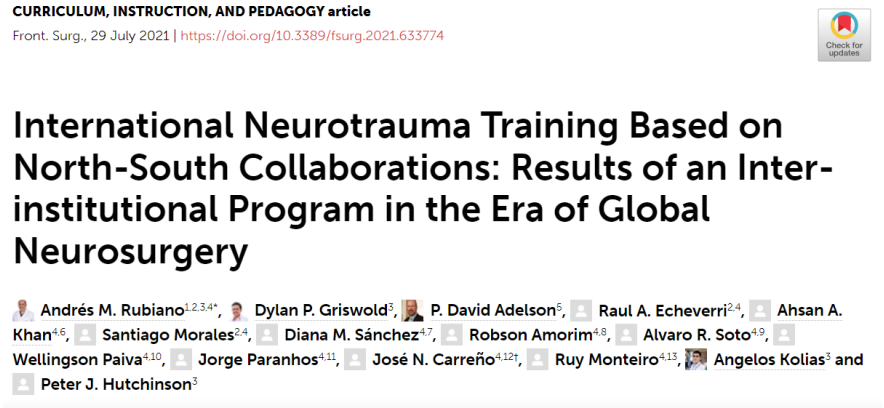




Section 3: Objective 3

TRACK-TBI
Transforming Research and Clinical Knowledge in Traumatic Brain Injury
International Traumatic Brain Injury Research Initiative

CENTER-TBI
Collaborative European Neurotrauma Effectiveness Research



CURRICULUM, INSTRUCTION, AND PEDAGOGY article
Front. Surg., 29 July 2021 | https://doi.org/10.3389/fsurg.2021.633774

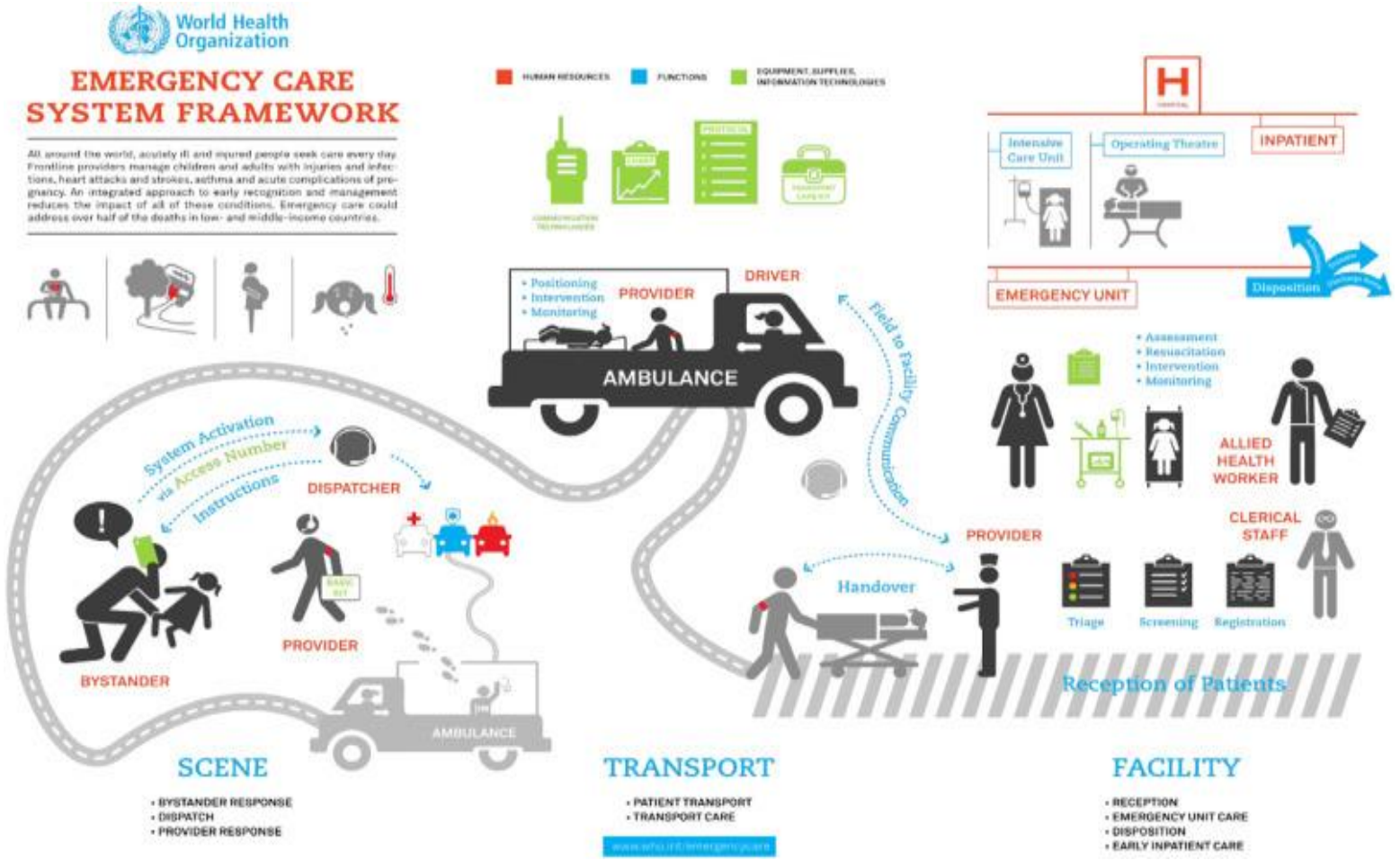
International Neurotrauma Training Based on North-South Collaborations: Results of an Inter-institutional Program in the Era of Global Neurosurgery

Andrés M. Rubiano[1,2,3,4*], Dylan P. Griswold[3], P. David Adelson[5], Raul A. Echeverri[2,4], Ahsan A. Khan[4,6], Santiago Morales[2,4], Diana M. Sánchez[4,7], Robson Amorim[4,8], Alvaro R. Soto[4,9], Wellingson Paiva[4,10], Jorge Paranhos[4,11], José N. Carreño[4,12†], Ruy Monteiro[4,13], Angelos Kolias[3] and Peter J. Hutchinson[3]

Rubiano AM, Griswold DP, Adelson PD et al. International Neurotrauma Training Based on North-South Collaborations: Results of an Inter-institutional Program in the Era of Global Neurosurgery. Front Surg. 2021 Jul 29;8:633774.

- "Share transitions from present to future trends in personalized and precision approaches that will impact the outcome of TBI patients within an organized care system".

Participating in the Development of Neurotrauma Care Systems



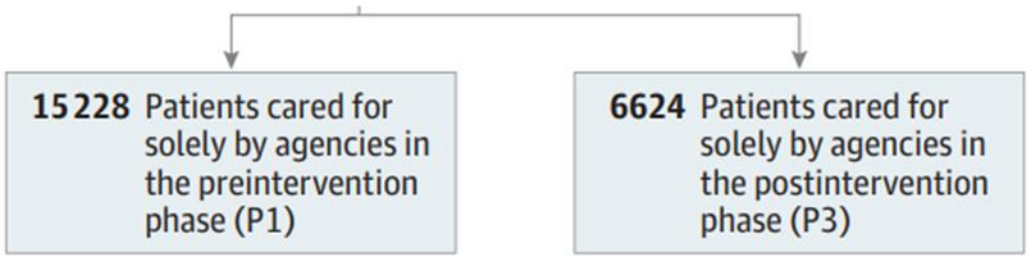
Reynolds TA, Sawe H, Rubiano AM, Shin SD, Wallis L, Mock CN. Strengthening Health Systems to Provide Emergency Care. In: Jamison DT, Gelband H, Horton S, et al., eds. Disease Control Priorities: Improving Health and Reducing Poverty. 3rd ed. Washington (DC): The International Bank for Reconstruction and Development / The World Bank; November 27, 2017

JAMA Surgery | Original Investigation

Association of Statewide Implementation of the Prehospital Traumatic Brain Injury Treatment Guidelines With Patient Survival Following Traumatic Brain Injury

The Excellence in Prehospital Injury Care (EPIC) Study

Daniel W. Spaite, MD; Bentley J. Bobrow, MD; Samuel M. Keim, MD, MS; Bruce Barnhart, RN, CEP; Vatsal Chikani, MPH; Joshua B. Gaither, MD; Duane Sherrill, PhD; Kurt R. Denninghoff, MD; Terry Mullins, MPH, MBA; P. David Adelson, MD; Amber D. Rice, MD, MS; Chad Viscusi, MD; Chengcheng Hu, PhD



PREHOSPITAL EMERGENCY CARE
2023, VOL. 27, NO. 5, 507–538
https://doi.org/10.1080/10903127.2023.2187905

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Taylor & Francis Group

BRAIN TRAUMA FOUNDATION TBI GUIDELINES

OPEN ACCESS Check for updates

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. Hawryluk[i], Scott A. Goldberg[j], Halim M. A. Hennes[k], Steven P. Ignell[b], Jamshid Ghajar[l], Brian P. Krzyzaniak[m], E. Brooke Lerner[n], 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]

[a]Department of Emergency Medicine, UT Southwestern Medical Center, Dallas, Texas; [b]Department of Emergency Medicine, Stanford University, Stanford, California; [c]Department of Medical Informatics and Clinical Epidemiology, Oregon Health & Science University, Portland, Oregon; [d]Department of Emergency Medicine, Icahn School of Medicine at Mount Sinai, New York, New York; [e]Department of Neurocritical Care, Neurology, Anesthesiology, Neurosurgery, University of Maryland School of Medicine, Baltimore, Maryland; [f]Uniformed Services University, Bethesda, Maryland; [g]Trauma Services, Queens Medical Center, Honolulu, Hawaii; [h]Hiram C. Polk Jr Department of Pediatric Surgery, University of Louisville, Norton Children's Hospital, Louisville, Kentucky; [i]Department of Neurosurgery, Cleveland Clinic and Akron General Hospital, Fairlawn, Ohio; [j]Department of Emergency Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts; [k]Department of Pediatric Emergency Medicine, UT Southwestern Medical Center, Dallas Children's Medical Center, Dallas, Texas; [l]Department of Neurosurgery, Stanford University, Stanford, California; [m]Menlo Park, California, United States; [n]Department of Emergency Medicine, Medical College of Wisconsin, Milwaukee, Wisconsin; [o]Department of Emergency Medicine, UC Davis, Sacramento, California; [p]Pediatric Critical Care, Cohen Children's Medical Center, Hofstra Northwell School of Medicine, Uniondale, New York; [q]Trauma and Critical Care, USAF Center for Sustainment of Trauma Readiness Skills, Seattle, Washington; [r]Department of Physical Therapy and Kinesiology, University of Massachusetts, Lowell, Massachusetts; [s]Department of Emergency Medicine, Emory University, Atlanta, Georgia; [t]University of Arizona College of Medicine-Phoenix, Phoenix, Arizona; [u]Department of Emergency Medicine, McGovern Medical School at The University of Texas Health Science Center at Houston (UTHealth), Houston, Texas

Comparative – Effectiveness Cohort Studies

Functional Outcomes Over the First Year After Moderate to Severe Traumatic Brain Injury in the Prospective, Longitudinal TRACK-TBI Study

Michael A. McCrea, PhD[1]; Joseph T. Giacino, PhD[2,3,4]; Jason Barber, MS[5]; et al

» Author Affiliations

JAMA Neurol. 2021;78(8):982-992. doi:10.1001/jamaneurol.2021.2043

ORIGINAL RESEARCH Open Access

Primary versus early secondary referral to a specialized neurotrauma center in patients with moderate/severe traumatic brain injury: a CENTER TBI study

Charlie Aletta Sewalt[1*], Benjamin Yaël Gravesteijn[1,2], David Menon[3], Hester Floor Lingsma[1], Andrew I. R. Maas[4], Nino Stocchetti[5], Esmee Venema[1,6] and Fiona E. Lecky[7]CENTER TBI Participants and Investigators

Clinical Registries for CE Studies in LMICs

https://www.latinotbi.com/

https://www.latinotbi.com/

El estudio "Registro Latinoamericano y del Caribe para Neurotrauma Craneal (LATINO-TBI)" es un proyecto de desarrollo de capacidad para apoyar el estudio del neurotrauma en la región latinoamericana y del caribe.

El registro electrónico funciona como un repositorio de bases de datos institucionales que permiten comprender y analizar las dinámicas de intervención en estos pacientes, asociándolas con desenlaces clínicos de acuerdo con estándares de investigación clínica internacional

Instituciones

FUNDACIÓN MEDITECH

Fundamentados en la importancia de la carga de esta enfermedad en la región, la Fundación **MEDITECH** de Colombia, en conjunto con organizaciones académicas de apoyo han generado este registro electrónico.

Specialized Neurotrauma Training Programs in LMICs

Fellow Directors Board

In 2020, applications were received from:

Cuba, Pakistan, Nepal, Egypt, Venezuela, Qatar, Uzbekistan and Emirates.

Surgical / Critical Care / Research Rotations in:

Colombia, Brazil, USA, UK and Bolivia

Graduated from the Program:

Colombia: 3 Fellows
Brazil: 3 Fellows
Cuba: 1 Fellow
Venezuela: 1 Fellow
Pakistan: 1 Fellow

CME Programs Integrating Neurotrauma Systems Concepts

NEUROSURGICAL FOCUS

Neurosurg Focus 48 (3):E1, 2020

INTRODUCTION

Neurosurgical international education

Isabelle M. Germano, MD, MBA,[1] Najia El Abbadi, MD,[2] Katharine Drummond, MBBS, MD, FRACS,[3] Andrés Rubiano, MD,[4] William F. J. Harkness, MD,[5] and Franco Servadei, MD[6]

[1]Department of Neurosurgery, Icahn School of Medicine at Mount Sinai, New York, New York; [2]Department of Neurosurgery, International Cheikh Zaid Hospital, Abulcassis University of Health Sciences, Rabat, Morocco; [3]Department of Neurosurgery, Royal Melbourne Hospital, University of Melbourne, Parkville, Victoria, Australia; [4]Neurological Surgery Program, Department of Neurosurgery and Neurosciences Institute, Universidad El Bosque, Bogotá, Colombia; [5]Department of Neurosurgery, Department of Clinical Neurosciences, UCL-Institute of Child Health, London, United Kingdom; and [6]Department of Neurosurgery, Humanitas University, Milan, Italy

NEUROSURGICAL FOCUS

Neurosurg Focus 48 (3):E13, 2020

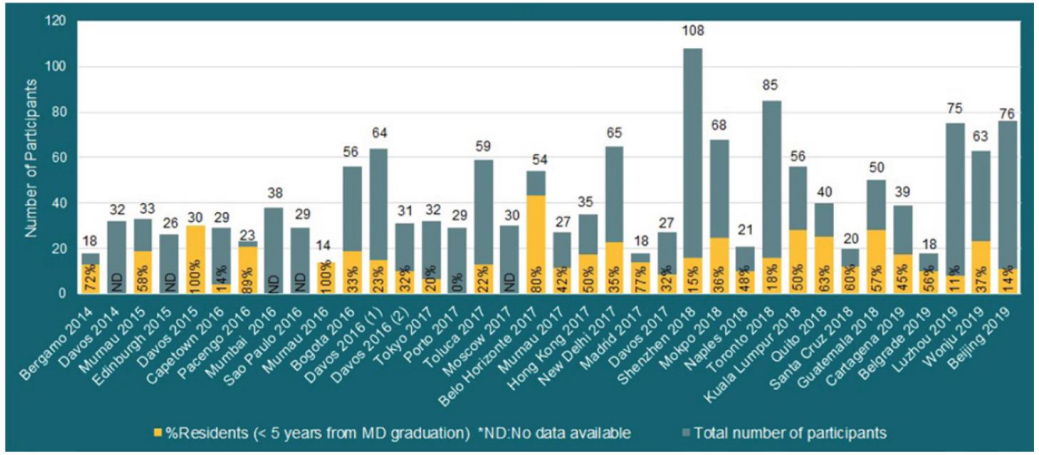
Development and assessment of competency-based neurotrauma course curriculum for international neurosurgery residents and neurosurgeons

Sergio A. Calero-Martinez, MD,[1,2] Christian Matula, MD,[3] Aurelia Peraud, MD, PhD,[4] Francesco Biroli, MD,[5] José Fernández-Alén, MD, PhD,[6] Michael Bierschneider, MD,[7] Michael Cunningham, PhD,[8] Gregory W. J. Hawryluk, MD, PhD,[9] Maya Babu, MD, MBA,[10] M. Ross Bullock, MD, PhD,[11] and Andrés M. Rubiano, MD[1,12,13]

[1]Meditech Foundation, Cali, Colombia; [2]Clemenshospital Münster, Germany; [3]Department of Neurosurgery, Medical University of Vienna, Austria; [4]University Hospital of Ulm, Germany; [5]Fondazione per la Ricerca Ospedale Maggiore, Bergamo, Italy; [6]Hospital 12 de Octubre, Madrid, Spain; [7]BG Unfallklinik Murnau, Germany; [8]AO Education Institute, AO Foundation, Dubendorf, Switzerland; [9]University of Manitoba, Winnipeg, Manitoba, Canada; [10]Massachusetts General Hospital, Boston, Massachusetts; [11]University of Miami, Florida; [12]Universidad El Bosque, Bogota, Colombia; and [13]Global Neuro Foundation, Davos, Switzerland

TABLE 2. Competencies for the Global Neurotrauma Curriculum

Perform basic assessment in an emergency situation
Integrate into interdisciplinary management
Decide appropriate investigations, interpret the results, and react appropriately
Select and perform operative procedures
Select and perform nonoperative procedures
Manage ICP
Prevent, identify, and manage complications
Organize rehabilitation transfer and follow-up
Apply guidelines specific to neurotrauma
Communicate with the patient, relatives, and colleagues



Global Neuro Foundation – Neurotrauma Track

Neurotrauma

Pre-Register

22 January - 22 May 2024
| Online

Global Neuro Online Certificate Course—Fundamentals of Neurotrauma Care for Nurses

The online certificate course in Fundamentals of Neurotrauma Care will allow nurses to receive up to date content from the experts that developed most of the actual medical evidence in the field and will also allow scheduled online interaction for students, led by our network of neurotrauma nursing experts.

Neurotrauma

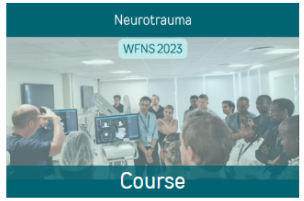
Registration closed

24 July - 31 December 2023

Global Neuro—Comprehensive Online Diploma in Neurotrauma Care

This Global Neuro Comprehensive Online Diploma in Neurotrauma Care has been developed for neurosurgeons and other health care providers, including residents, dedicated to the integral management of Neurotrauma, as well as complex and interdisciplinary patient care.

The program is endorsed by the WFNS Neurotraumatology Committee and WFNS Young Neurosurgeons Forum.



Neurotrauma

Open for registration

03 - 04 December 2023
South Africa | Cape Town

Global Neuro Course—Neurotrauma at the XVIII World Congress of Neurosurgery WFNS 2023

Course Chairs:
Andres M. Rubiano, El bosque University, Colombia
Mario Ganau, Oxford University, United Kingdom

VALLESALUD

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Evaristo García E.S.E.

Universidad del Valle

andresrubiano@aol.com

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