Brain dysfunction in sepsis

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The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3)

Box 3. New Terms and Definitions

- Sepsis is defined as life-threatening organ dysfunction caused by a dysregulated host response to infection.
- Organ dysfunction can be identified as an acute change in total SOFA score ≥2 points consequent to the infection.

Table 1. Sequential [Sepsis-Related] Organ Failure Assessment Score[a]

	Score				
System	0	1	2	3	4
Respiration					
(μmol/L)					
Urine output, mL/d				<500	<200

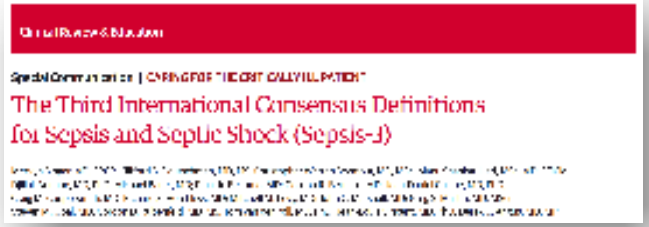
- A SOFA score ≥2 reflects an overall mortality risk of approximately 10% in a general hospital population with suspected infection. Even patients presenting with modest dysfunction can deteriorate further, emphasizing the seriousness of this condition and the need for prompt and appropriate intervention, if not already being instituted.

Abbreviations: FIO_2, fraction of inspired oxygen; MAP, mean arterial pressure; PaO_2, partial pressure of oxygen.

[a] Adapted from Vincent et al.[27]

[b] Catecholamine doses are given as μg/kg/min for at least 1 hour.

[c] Glasgow Coma Scale scores range from 3-15; higher score indicates better neurological function.



The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3)

- Patients with suspected infection who are likely to have a prolonged ICU stay or to die in the hospital can be promptly identified at the bedside with qSOFA, ie, alteration in mental status, systolic blood pressure ≤100 mm Hg, or respiratory rate ≥22/min.

Box 4. qSOFA (Quick SOFA) Criteria

Respiratory rate ≥22/min

Altered mentation

Systolic blood pressure ≤100 mm Hg

Brain dysfunction in sepsis

- Definitions
- Risk factors and outcomes
- Is clinical evaluation feasible ?
- Does EEG help ?
- Biomarkers ?
- When should we perform brain MRI ?
- Major confounders
- Conclusion

Sepsis-associated encephalopathy

Teneille E. Gofton and G. Bryan Young

Diffuse cerebral dysfunction that accompanies sepsis, **in the absence of direct CNS infection**

Early feature of infection and might appear **before other systemic features of sepsis.**

Many synonyms have been used in the literature to describe the same entity (encephalopathy, brain dysfunction….)

At sepsis onset, many patients with **SAE** usually meet diagnostic criteria for **delirium or coma**

Nat Review Neurol 2012

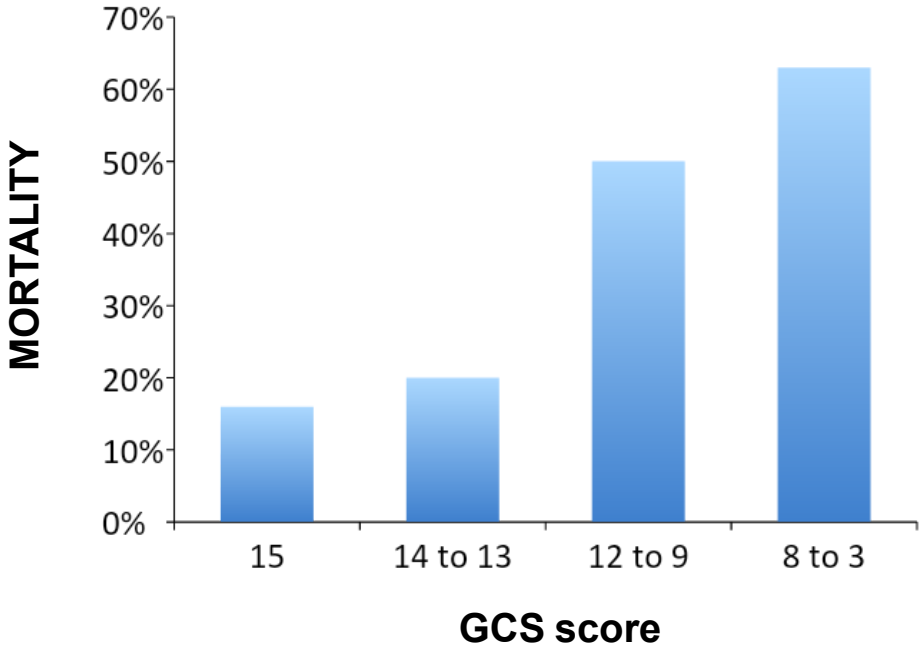
The Spectrum of Septic Encephalopathy

Definitions, Etiologies, and Mortalities

Lecnic A. Eidelman, MD; Debby Putterman, MD; Chaim Putterman, MD; Charles L. Sprung, MD

N=50 non-sedated patients with severe sepsis / septic shock

Septic encephalopathy, as defined by a GCS < 15 : **27 (54%) patients**



JAMA 1996

ORIGINAL

Potentially modifiable factors contributing to sepsis-associated encephalopathy

Romain Sonneville[1,2*], Etienne de Montmollin[3,4], Julien Poujade[1], Maité Garrouste-Orgeas[2,5], Bertrand Souweine[6], Michael Darmon[3,4], Eric Mariotte[7], Laurent Argaud[8,9], François Barbier[1,10], Dany Goldgran-Toledano[11], Guillaume Marcotte[12], Anne Sylvie Dumenil[11], Sami Ruimal[13], Guillaume Lacave[14], Stéphane Ruckly[2], Bruno Mourvillier[1,3] and Jean-François Timsit[1,3]

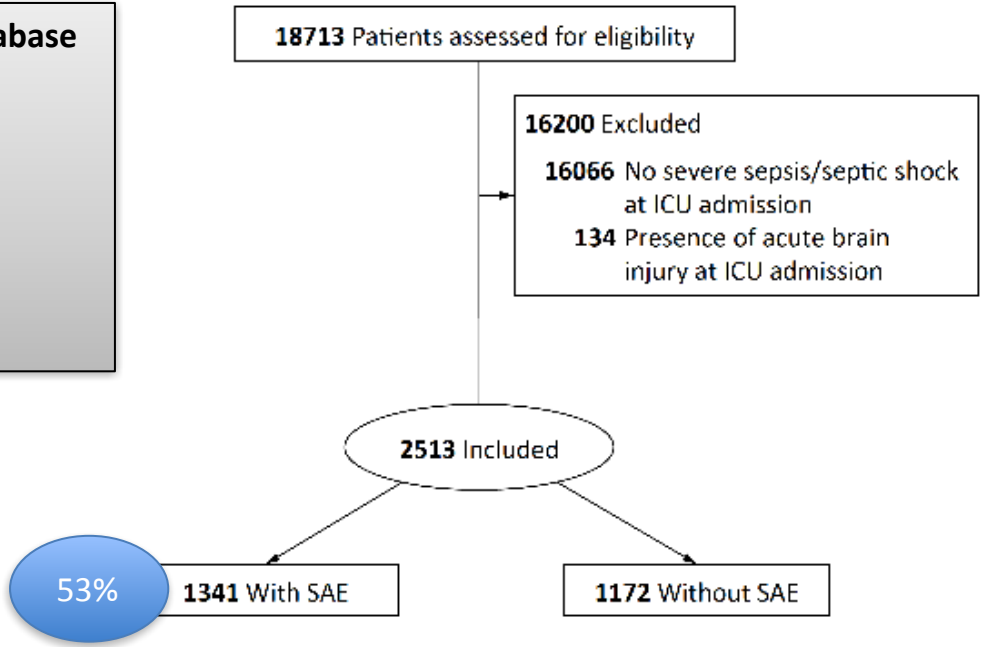
Retrospective analysis of a **prospective multicenter database** 1997-2014, 17 ICUs in France

SAE defined **at ICU admission** by

- A score on **GCS < 15**

OR

- when **features of delirium** were noted



Intensive Care Medicine 2017

Brain dysfunction in sepsis

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- Conclusion

REVIEW Open Access

Understanding brain dysfunction in sepsis

Romain Sonneville[1,2], Franck Verdonk[2], Camille Rauturier[2], Isabelle F Klein[3], Michel Wolff[1], Djillali Annane[4], Fabrice Chretien[2] and Tarek Sharshar[2,4]*

Sepsis

Immobilisation
Restraints, catheters…

Environnement
Noise, light exposure…..

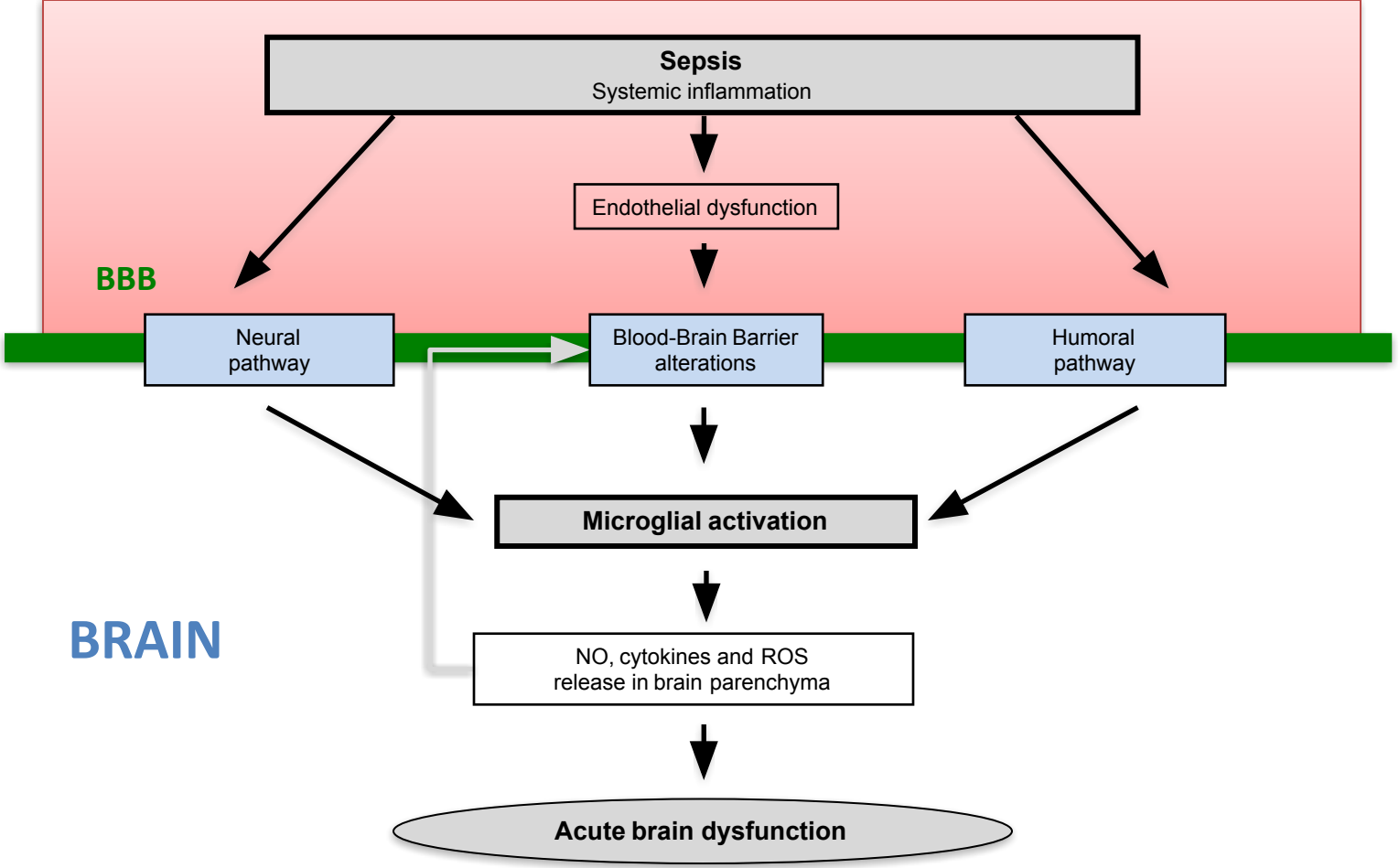
Delirium
Coma

Cognitive and functional impairment

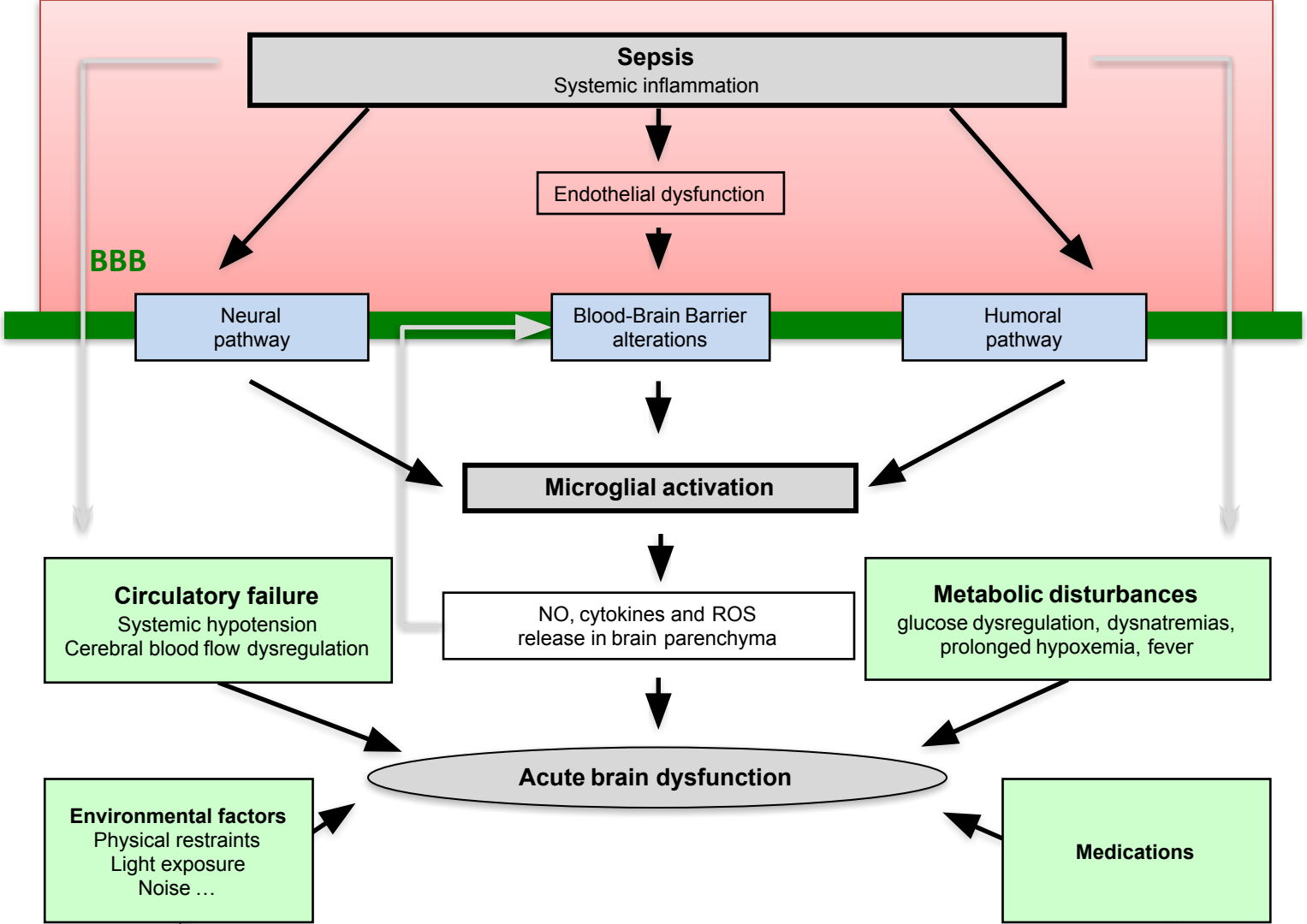
Neurotoxicity
Sedation (BZD)
Antibiotics (Betalact., FQ….)

Predisposing factors
Age, neurocognitive disorders, HTA…

Annals of intensive Care, 2013

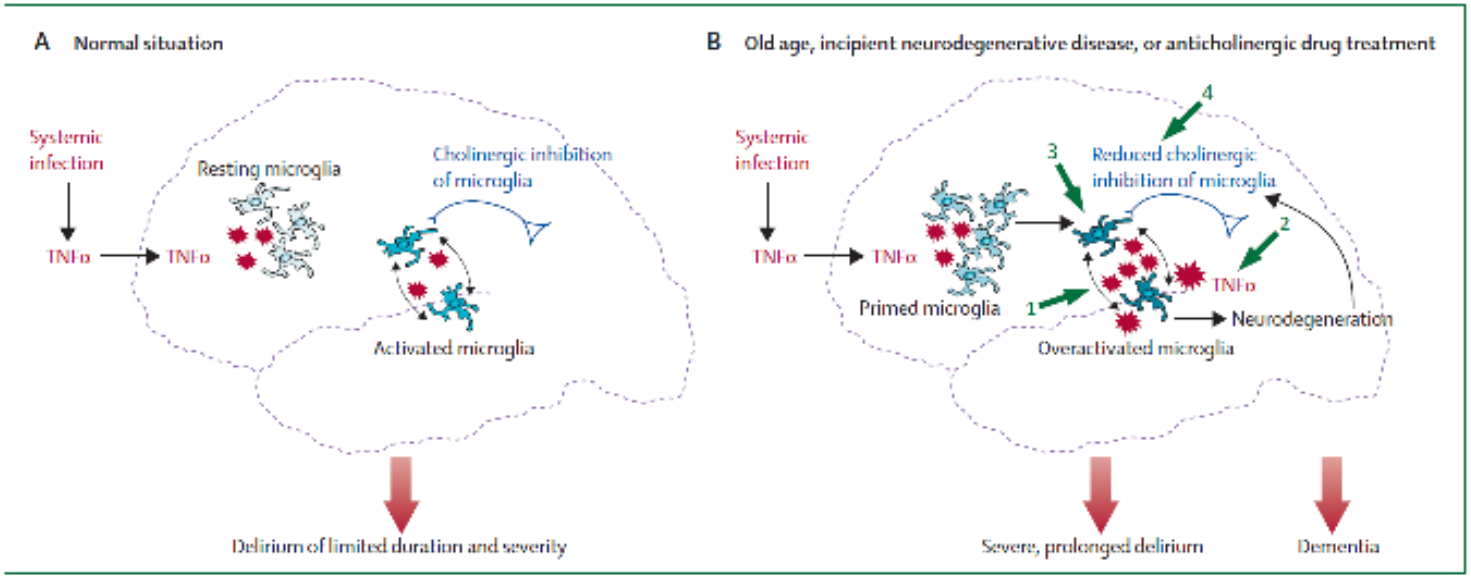


R Sonneville, Annals of intensive care 2013


Sepsis
Systemic inflammation
Endothelial dysfunction
BBB
Neural pathway
Blood-Brain Barrier alterations
Humoral pathway
Microglial activation
Circulatory failure
Systemic hypotension
Cerebral blood flow dysregulation
NO, cytokines and ROS release in brain parenchyma
Metabolic disturbances
glucose dysregulation, dysnatremias, prolonged hypoxemia, fever
Acute brain dysfunction
Environmental factors
Physical restraints
Light exposure
Noise …
Medications

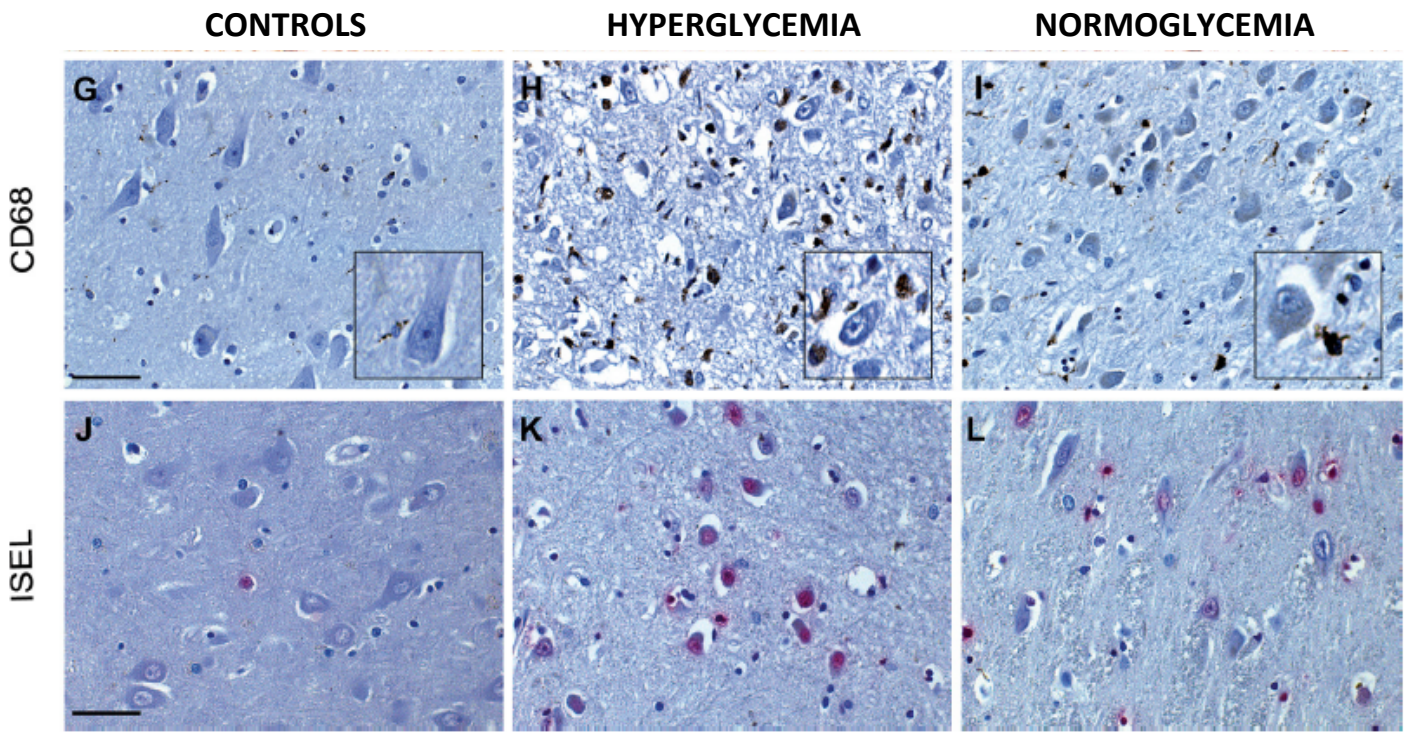
Systemic infection and delirium: when cytokines and acetylcholine collide

Willem A van Gool, Diederik van de Beek, Piet Eikelenboom



Lancet 2010; 375: 773–75

Impact of Hyperglycemia on Neuropathological Alterations during Critical Illness



R Sonneville, J Clin Endoc Metab 2012

ORIGINAL

Potentially modifiable factors contributing to sepsis-associated encephalopathy

Romain Sonneville[1,2*], Etienne de Montmollin[3,4], Julien Poujade[1], Maité Garrouste-Orgeas[2,5], Bertrand Souweine[6], Michael Darmon[3,4], Eric Mariotte[7], Laurent Argaud[8,9], François Barbier[10], Dany Goldgran-Toledano[11], Guillaume Marcotte[12], Anne Sylvie Dumenil[13], Sami Ruckly[1], Guillaume Lacave[14], Stéphane Ruckly[2], Bruno Mourvillier[1,3] and Jean-François Timsit[1,2]

Risk factors for sepsis-associated encephalopathy, multivariate analysis

Variable	OR	95% CI		*p* value
Age, per 1-year increment	1.02	1.01	1.02	<0.01
Chronic alcohol abuse	3.38	2.34	4.89	<0.01
History of neurological disease	1.56	1.18	2.06	<0.01
Pre-existing cognitive impairment	2.25	1.09	4.67	0.03
Long-term use of psychoactive drugs	1.37	1.11	1.70	<0.01
Medical admission[a]	1.75	1.43	2.14	<0.01
Renal SOFA > 2	1.41	1.19	1.67	<0.01
Hypoglycemia, <3 mmol/l	2.66	1.27	5.59	<0.01
Hyperglycemia, >10 mmol/l	1.37	1.09	1.72	<0.01
Hypercapnia, >45 mmHg	1.91	1.53	2.38	<0.01
Hypernatremia, >145 mmol/l	2.30	1.48	3.57	<0.01

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ORIGINAL

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Short term outcomes

Variable	No SAE N=1172	SAE N=1341	p
Need for invasive MV, n (%)	588 (50)	1039 (78)	<0.01
Need for propofol or BZD, n (%)	423 (36)	796 (59)	<0.01
Need for vasopressors, n (%)	803 (69)	1067 (80)	<0.01
Need for RRT, n (%)	231 (20)	411 (31)	<0.01
Length of ICU stay, days			
Whole population	5 (3-12)	7 (3-15)	<0.01
Survivors (n=1539)	5 (3-11)	9 (5-17)	<0.01

Data are numbers (percentage) or median (IQR)

ORIGINAL

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Multivariate analyis of factors associated with mortality (censored at day 30)

Variable	Adjusted HR*	95%CI	p
Sepsis-associated encephalopathy			< 0.01
GCS 3-8	3.37	2.82-4.03	
GCS 9-12	1.80	1.41-2.29	
GCS 13-14	1.38	1.09-1.76	
GCS 15, features of delirium	1.06	0.80-1.41	
GCS 15, no feature of delirium	Ref.		

**Adjusted for age, chronic immunodepression, chronic cardiac disease, chronic respiratory disease, chronic liver disease, year of admission, and non-neurological SOFA*

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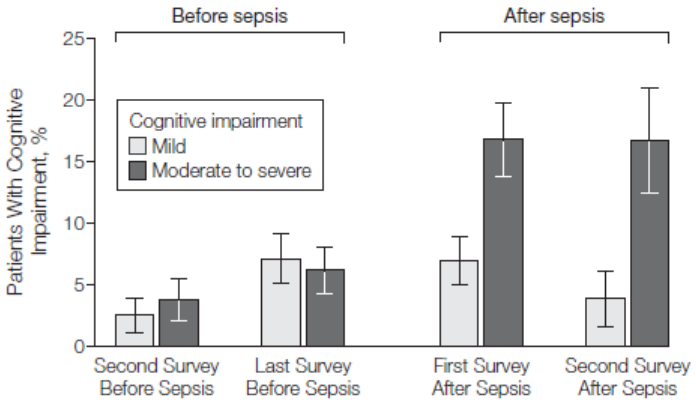
Long-term Cognitive Impairment and Functional Disability Among Survivors of Severe Sepsis

Figure 2. Cognitive Impairment Among Survivors of Severe Sepsis at Each Survey Time Point



	Second Survey Before Sepsis	Last Survey Before Sepsis	First Survey After Sepsis	Second Survey After Sepsis
Time to sepsis admission, median (IQR), y	−3.1 (−3.7 to −2.7)	−1.1 (−1.7 to −0.7)	0.9 (0.4 to 1.4)	2.8 (2.3 to 3.4)
No. of patients	484	623	623	288

Error bars indicate 95% confidence intervals (CIs); IQR, interquartile range.
Interpretive Example: Compared with stable rates before severe sepsis, the prevalence of moderate to severe cognitive impairment increased from 6.1% (95% CI, 4.2%-8.0%) before severe sepsis to 16.7% (95% CI, 13.8%-19.7%) at the first survey after severe sepsis ($P < .001$ by χ^2 test; Table 2).

Iwashyna, JAMA 2010


EDITORIAL

Editorials represent the opinions of the authors and JAMA and not those of the American Medical Association.

The Lingering Consequences of Sepsis

A Hidden Public Health Disaster?

SEPSIS

Long term cognitive impairment

Functional dependence

Angus DC, JAMA 2010

Cognition

RESEARCH PAPER

Persistent cognitive impairment, hippocampal atrophy and EEG changes in sepsis survivors

Alexander Semmler,[1,6] Catherine Nichols Widmann,[1] Thorsten Okulla,[1] Horst Urbach,[2] Markus Kaiser,[3,7] Guido Widman,[4] Florian Mormann,[4,8] Julia Weide,[1] Klaus Fliessbach,[4] Andreas Hoeft,[3] Frank Jessen,[5] Christian Putensen,[3] Michael T Heneka[1]

- **Cognitive deficits :**
  - verbal learning
  - Short term memory
- **MRI :** significant reduction of hippocampal volume
- **EEG :** low-frequency activity indicating unspecific brain dysfunction

J Neurol Neurosurg Psychiatry 2013;**84**:62–70. doi:10.1136/jnnp-2012-302883

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WHAT'S NEW IN INTENSIVE CARE

Ten false beliefs in neurocritical care

Geert Meyfroidt[1,2*], David Menon[3,4,5,6,7] and Alexis F. Turgeon[8]

2. Clinical examination of neurocritically ill patients is impossible.

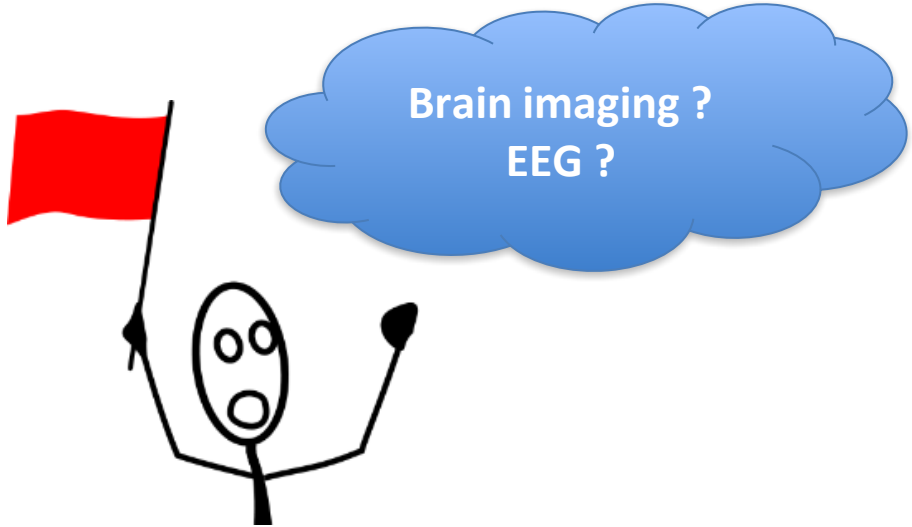
“Red flags”

- Poor motor response (GCS) : M < 3
- Focalization

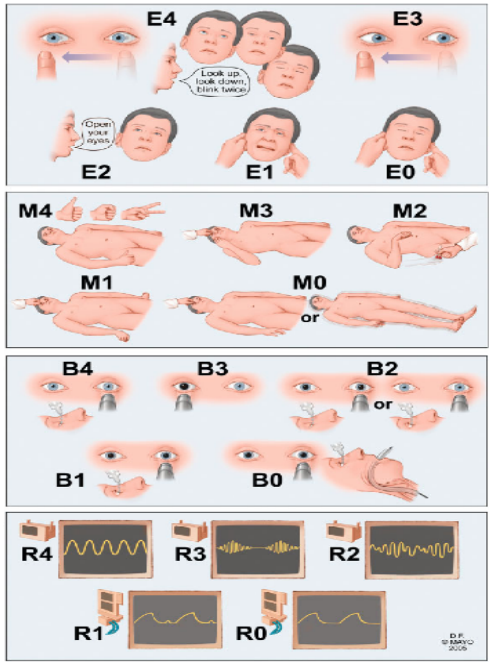
- ICU-acquired seizure(s)

- Loss of brainstem reflex(es)
  - pupillary reflex
  - corneal reflex
  - cough

- Myoclonus



Validation of a New Coma Scale: The FOUR Score



FOUR Score

Eye response
- 4 = eyelids open or opened, tracking, or blinking to command
- 3 = eyelids open but not tracking
- 2 = eyelids closed but open to loud voice
- 1 = eyelids closed but open to pain
- 0 = eyelids remain closed with pain

Motor response
- 4 = thumbs-up, fist, or peace sign
- 3 = localizing to pain
- 2 = flexion response to pain
- 1 = extension response to pain
- 0 = no response to pain or generalized myoclonus status

Brainstem reflexes
- 4 = pupil and corneal reflexes present
- 3 = one pupil wide and fixed
- 2 = pupil or corneal reflexes absent
- 1 = pupil and corneal reflexes absent
- 0 = absent pupil, corneal, and cough reflex

Respiration
- 4 = not intubated, regular breathing pattern
- 3 = not intubated, Cheyne Stokes breathing pattern
- 2 = not intubated, irregular breathing
- 1 = breathes above ventilator rate
- 0 = breathes at ventilator rate or apnea

FOUR = Full Outline of UnResponsiveness.

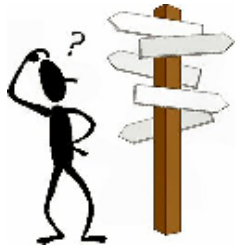
The FOUR score provides **greater neurological detail** than the GCS, **recognizes a locked-in syndrome**, and is superior to the GCS due to the availability of **brainstem reflexes**, **breathing patterns**, and the ability to recognize different stages of **herniation.**

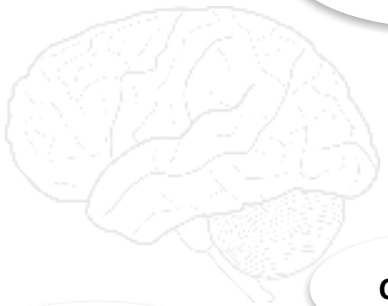
Wijdicks, Ann Neurol 2005

Early multimodal non-invasive monitoring

Clinical evaluation
(GCS, CAM-ICU…)

Biomarkers
(NSE, S100b)





CT, MRI

EEG
Evoked
potentials

Functional
outcome ?

Minerva anesthesiologica 2015

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Sepsis-associated encephalopathy

Jenelle E. Gofton and G. Bryan Young

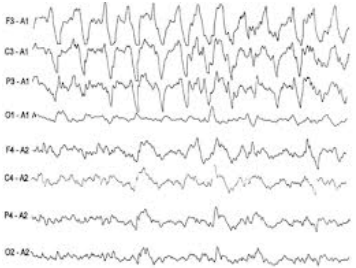


Table 1 | Changes in EEG recordings in patients with SAE*

Degree of encephalopathy	EEG findings (% of patients)				
	Normal	Theta waves	Delta waves	Triphasic waves	Burst–suppression pattern
None	50	38	12	0	0
Mild	0	47	54	0	0
Severe	0	10	40	20	30

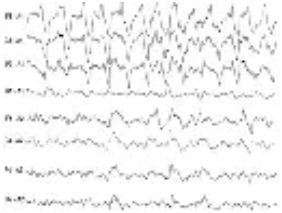
* Generated from data provided by Young *et al.*[86] Abbreviation: SAE, sepsis-associated encephalopathy.

Nat Review Neurol 2012

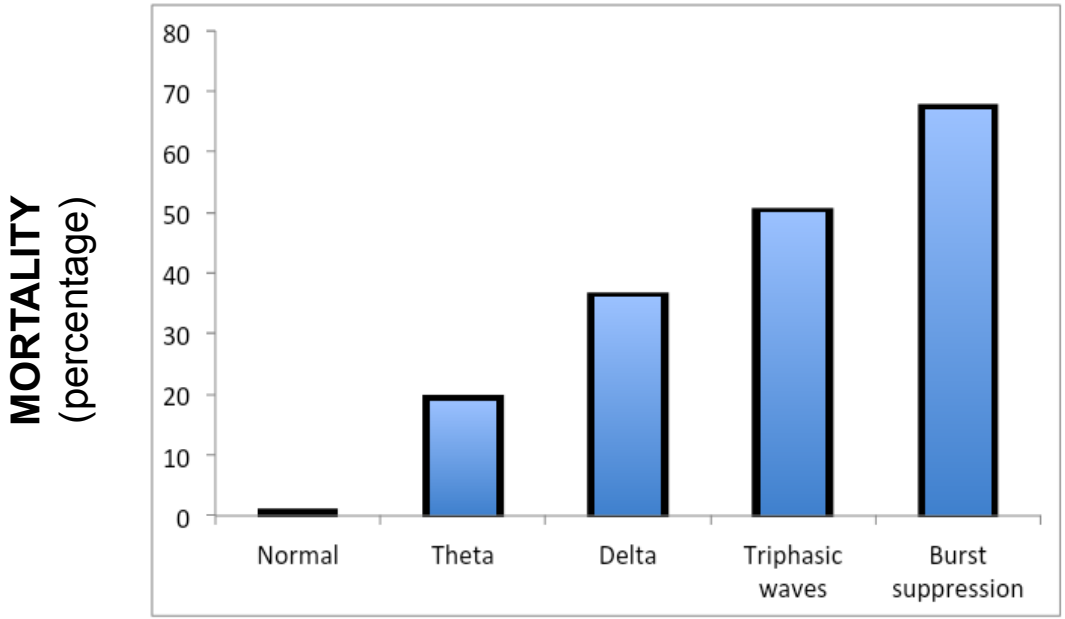
Young et al., J Clin Neurophysiol 1992

Sepsis-associated encephalopathy

Jenelle E. Gofton and G. Bryan Young



EEG CHANGES AND OUTCOMES



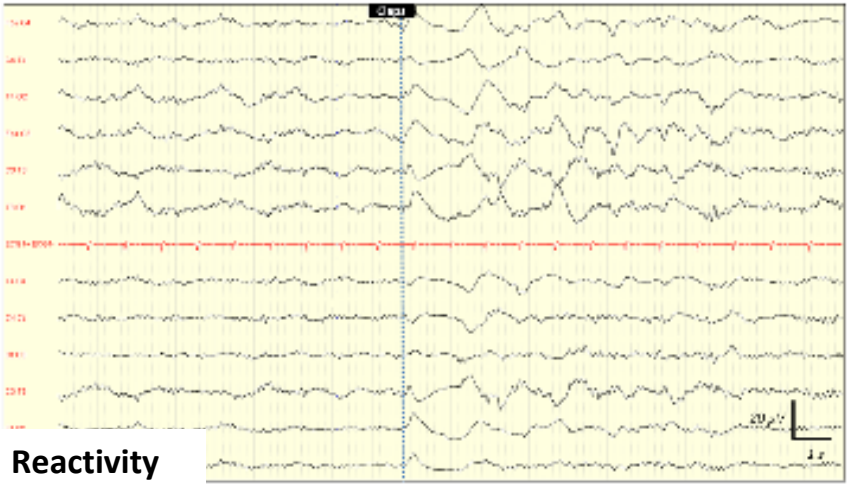
Nat Review Neurol 2012

Young et al., J Clin Neurophysiol 1992

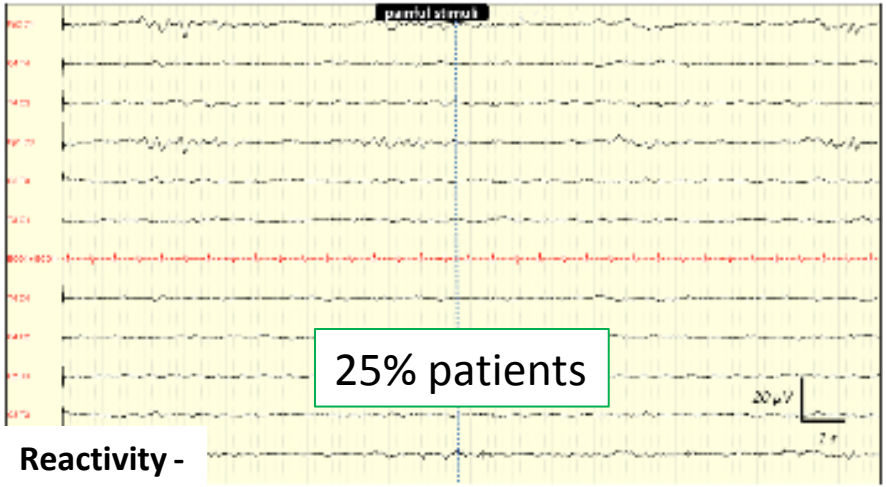
PLOS ONE

Early Standard Electroencephalogram Abnormalities Predict Mortality in Septic Intensive Care Unit Patients

Eric Azabou, Eric Magalon, Antoine Braconnier, Lyne Yahiaoui, Guy Moneyron, Nicholas Heming, Gilles Annane, Jean Sharshar, Fabrice Chrétien, Marie-Christine Jaouen, Frédéric Lofaso, Raphael Porcher, Tarek Sharshar



Reactivity +



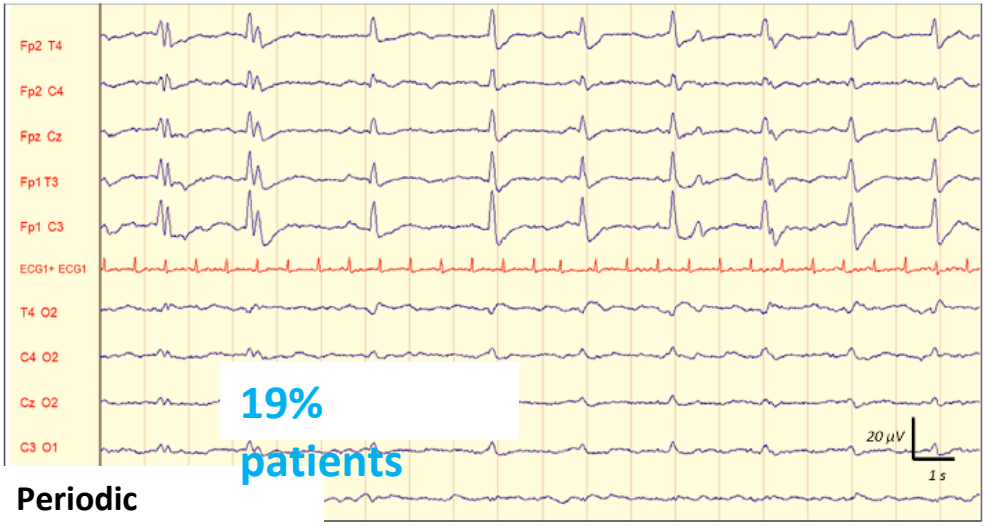
Reactivity -

Plos One 2015

PLOS ONE

Early Standard Electroencephalogram Abnormalities Predict Mortality in Septic Intensive Care Unit Patients

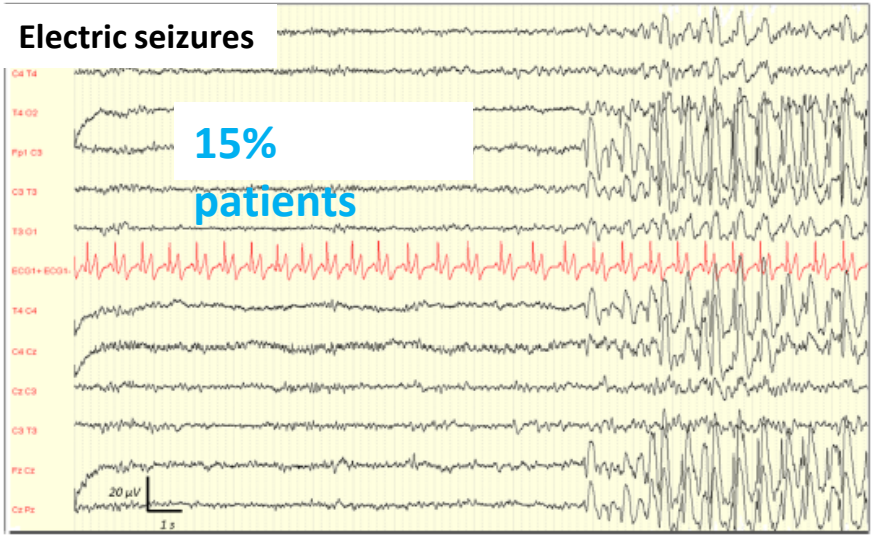
[illegible]



19% patients

Periodic discharges

Electric seizures



15% patients

Plos One 2015

PLOS ONE

Early Standard Electroencephalogram Abnormalities Predict Mortality in Septic Intensive Care Unit Patients

Erik Azabou, Eric Magalon, Antonin Braconnier, Lynn Yahiaoui, Guy Moneyron, Nicholas Heming, Djillali Annane, Jean Sharshar, Fabrice Chrétien, Marie-Christine Jaouen, Bérénice Lechat, Raphael Porcher, Tarek Sharshar

Table 4. Adjusted analysis of the association of EEG findings with day 28 mortality.

Variable	Adjusted on SAPS-II at admission and sedation			Adjusted on SOFA at EEG and sedation		
	OR	(95%CI)	P	OR	(95%CI)	P
Delta-dominant activity	3.36	(1.08 to 10.1)	0.036	3.08	(0.93 to 10.2)	0.066
Absence of reactivity	4.44	(1.37 to 14.3)	0.013	4.57	(1.36 to 15.4)	0.014
Periodic Discharges	3.24	(1.03 to 10.2)	0.044	3.31	(0.98 to 11.2)	0.054
Synek's score ≥ 3	5.35	(1.66 to 17.2)	0.005	5.68	(1.63 to 19.8)	0.006
Young's score > 1	3.44	(1.09 to 10.8)	0.035	3.43	(1.02 to 11.6)	0.046

Abbreviations: SAPS-II: New Simplified Acute Physiology Score; SOFA: Sepsis-related Organ Failure Assessment.

Plos One 2015

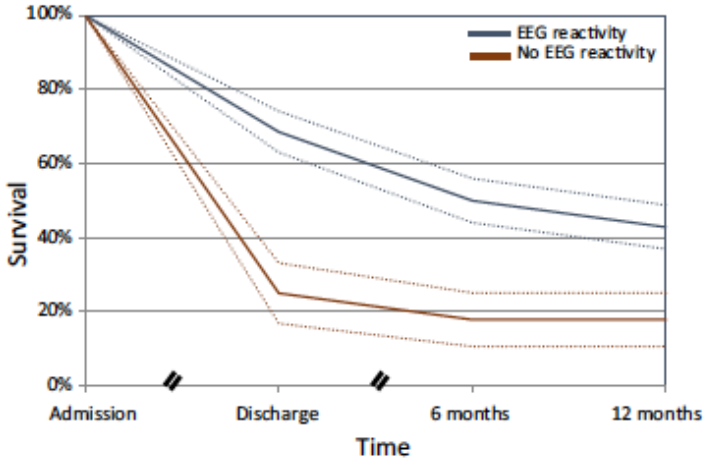
Intensive Care Med (2015) 41:686–694
DOI 10.1007/s00134-015-3709-1

ORIGINAL

Emily J. Gilmore
Nicolas Gaspard
Huimahn A. Choi
Emily Cohen
Kristin M. Burkart
David H. Chong
Jan Claassen
Lawrence J. Hirsch

Acute brain failure in severe sepsis: a prospective study in the medical intensive care unit utilizing continuous EEG monitoring

100 septic episodes in 98 patients
Periodic discharges : 25%
Non convulsive seizures : 10%
Unreactive EEG background : 28%



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- Conclusion

Admission plasma levels of the neuronal injury marker neuron-specific enolase are associated with mortality and delirium in sepsis

Brian J. Anderson, MD, MS [a,b,*], John P. Reilly, MD, MS [a], Michael G.S. Shashaty, MD, MS [a,b], Jessica A. Palakshappa, MD [a,b], Alex Wysoczanski [a], Thomas G. Dunn, BA [a], Altaf Kazi, PhD [a], Anna Tommasini, BA [a], Mark E. Mikkelsen, MD, MS [a,b], William D. Schweickert, MD [a], Dennis F. Kolson, MD, PhD [c], Jason D. Christie, MD, MS [a,b,1], Nuala J. Meyer, MD, MS [a,1]

Retrospective analysis of 124 patients from a large sepsis cohort.
Plasma NSE was measured in the earliest blood draw at intensive care unit admission.
Primary outcomes : 30-day mortality and ICU delirium (chart review)

SAE

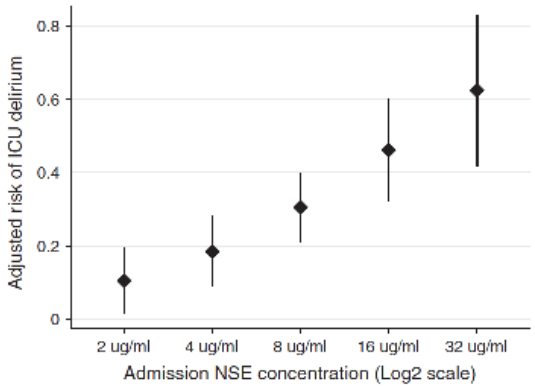


Fig. 3. Adjusted probability of delirium according to plasma NSE concentration at ICU admission. Points represent the adjusted delirium risk, and vertical error bars represent 95% CIs. The NSE concentration is plotted on the log base 2 scale. After adjustment for APACHE III score and receipt of sedative and analgesic infusions, each 2-fold increase in the plasma NSE concentration was associated with a 5.2% increased risk of delirium ($P < .001$).

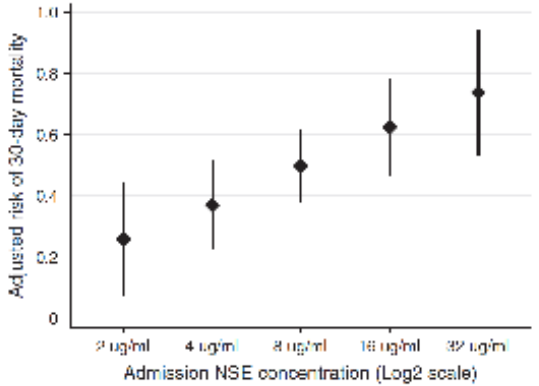


Fig. 2. Adjusted probability of 30-day mortality according to the plasma NSE concentration at ICU admission. Points represent the adjusted mortality risk, and vertical error bars represent 95% CIs. The NSE concentration is plotted on the log base 2 scale. After adjustment for APACHE III score, admission location, race, and ARDS, each 2-fold increase in the plasma NSE concentration was associated with a 7.3% increased risk of 30-day mortality ($P = .018$).

Mortality

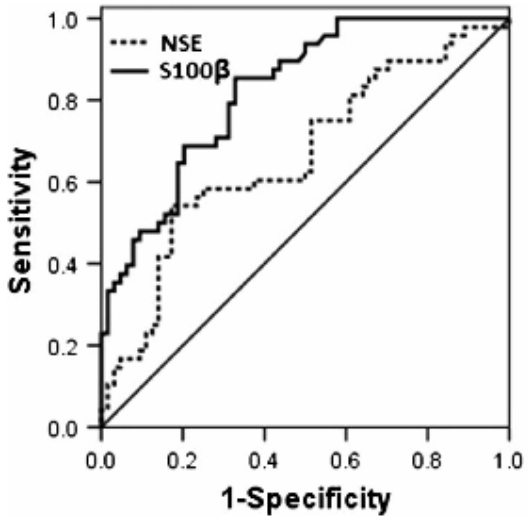
J Crit Care 2016

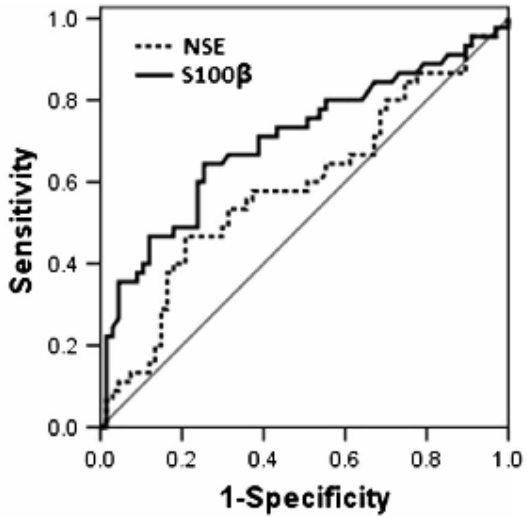
ORIGINAL PAPER

Serum S100β is a Better Biomarker than Neuron-Specific Enolase for Sepsis-Associated Encephalopathy and Determining Its Prognosis: A Prospective and Observational Study

Bo Yao · Li-Na Zhang · Yu-Hang Ai · Zhi-Yong liu · li Huang

SAE





Mortality

Neurochem research 2014

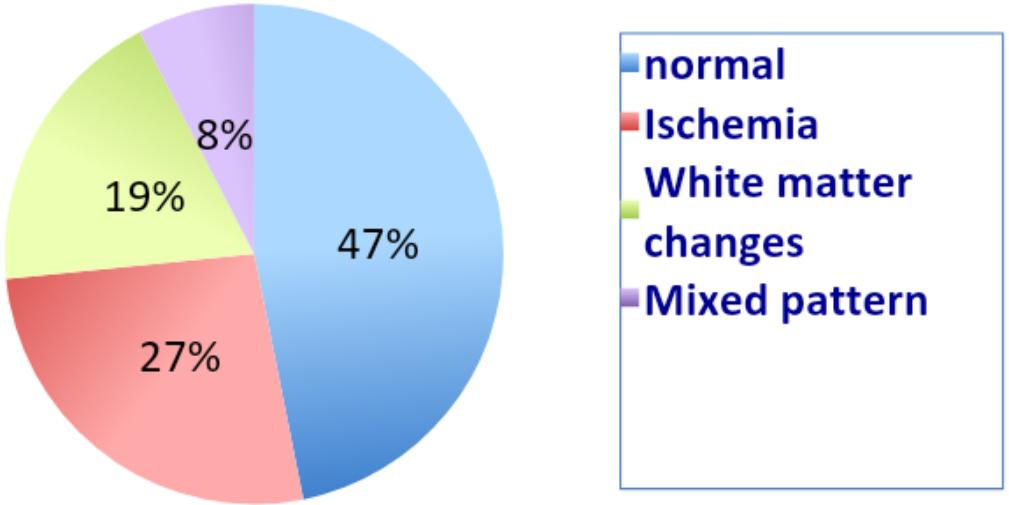
Brain dysfunction in sepsis

- Definitions
- Risk factors and outcomes
- Is clinical evaluation feasible ?
- Does EEG help ?
- Biomarkers ?
- When should we perform brain MRI ?
- Major confounders
- Conclusion

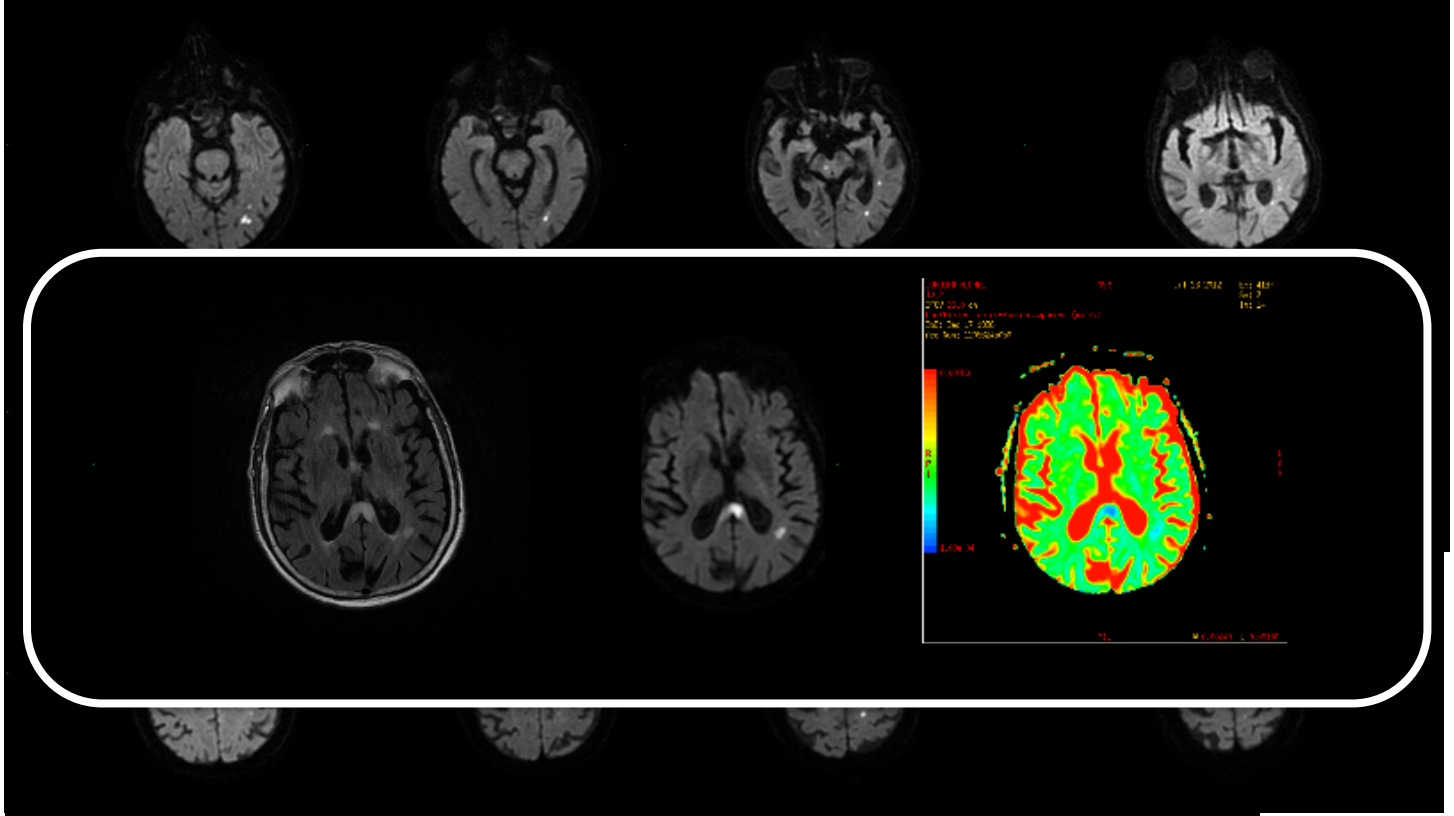
RESEARCH Open Access

Pattern of Brain Injury in the Acute Setting of Human Septic Shock

N=71 septic shock patients underwent MRI
because of encephalopathy, focal signs or seizures

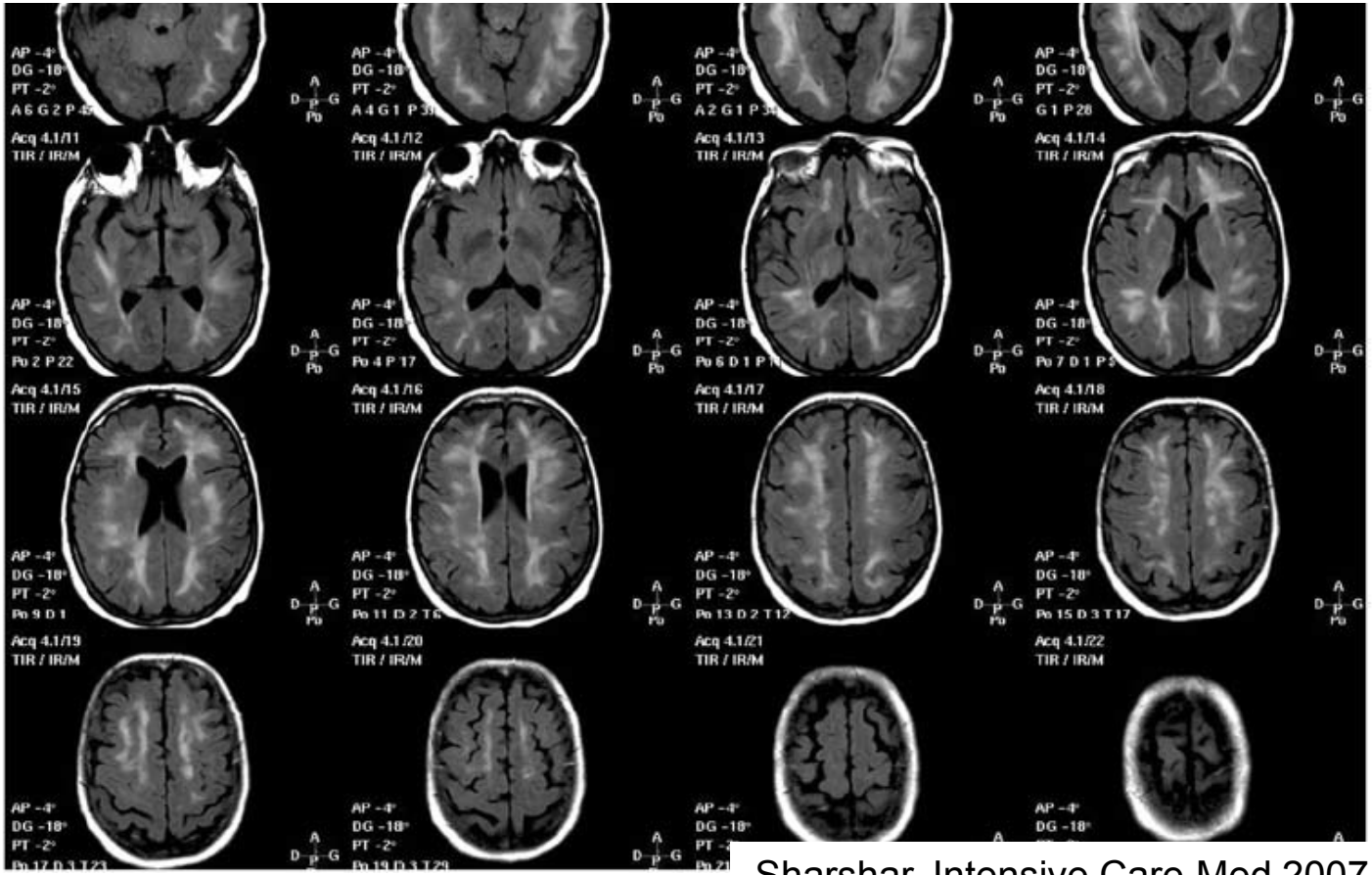


A Polito, Crit care 2013

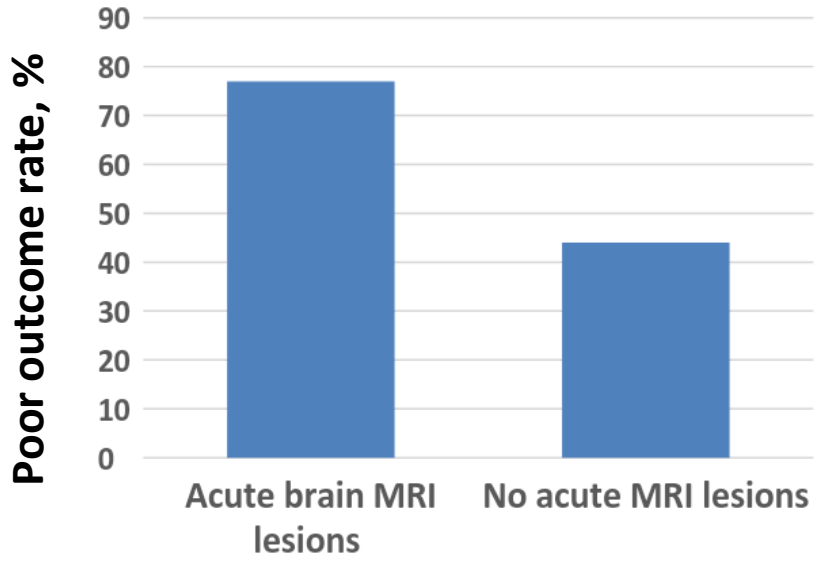


72 yr-old patient
Streptococcus pneumoniae pneumonia, normal CSF examination
Septic shock
Persistent encephalopathy

Brain lesions in septic shock: a magnetic resonance imaging study



Sharshar, Intensive Care Med 2007



Acute brain MRI lesions : 130/146 (89 %) pts

- White matter lesions (104/146, 71 %)
- Acute cerebral infarcts (59/146, 40 %).

Acute brain MRI lesions **were independently associated with**

Neurocritical care 2015

Brain dysfunction in sepsis

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DAILY INTERRUPTION OF SEDATIVE INFUSIONS IN CRITICALLY ILL PATIENTS UNDERGOING MECHANICAL VENTILATION

JOHN P. KRESS, M.D., ANNE S. POHLMAN, R.N., MICHAEL F. O'CONNOR, M.D., AND JESSE B. HALL, M.D.

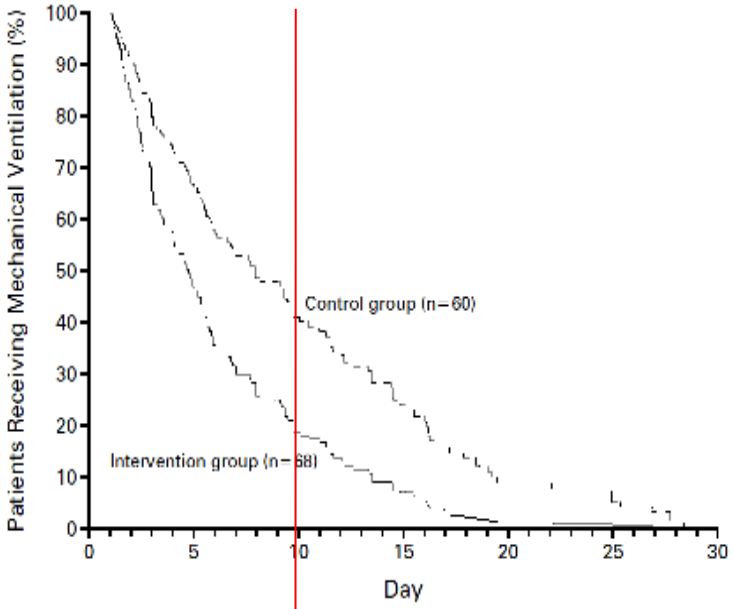

Figure 1. Kaplan–Meier Analysis of the Duration of Mechanical Ventilation, According to Study Group. After adjustment for base-line variables (age, sex, weight, APACHE II score, and type of respiratory failure), mechanical ventilation was discontinued earlier in the intervention group than in the control group (relative risk of extubation, 1.9; 95 percent confidence interval, 1.3 to 2.7; P<0.001).

Kress, N Eng J Med 2001

DAILY INTERRUPTION OF SEDATIVE INFUSIONS IN CRITICALLY ILL PATIENTS UNDERGOING MECHANICAL VENTILATION

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128 patients in MICU
Intervention: Interruption of sedative infusions until patients awake, on a daily basis
Control: the infusions were interrupted only at the discretion of the clinicians

	Intervention (n=68)	**Control (n=60)**	**p**
Total dose of MDZ, mg	230 (59–491)	425 (208–824)	.05
Total dose of morphine, mg	205 (68–393)	481 (239–748)	.009
Median duration of MV, days	4.9	7.3	.004
Median duration of ICU stay, days	6.4	9.9	.02
Diagnostic testing to assess change in mental status, n (%)	6 (9%)	16 (27%)	.02
Complications (e.g., self-extubation)	3 (4%)	4 (7%)	.88

Kress, N Eng J Med 2001

Effect of Sedation With Dexmedetomidine vs Lorazepam on Acute Brain Dysfunction in Mechanically Ventilated Patients

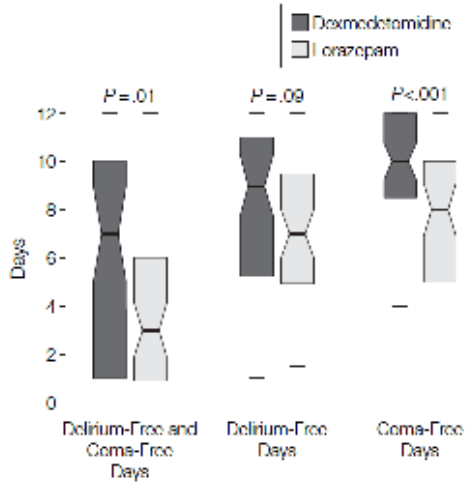
The MENDS Randomized Controlled Trial

Table 2. Outcomes in Mechanically Ventilated Patients Sedated With Dexmedetomidine vs Lorazepam[a]

Outcome Variable	Dexmedetomidine (n = 52)	Lorazepam (n = 51)	*P* Value
Duration of brain organ dysfunction, d			
Delirium-free and coma-free[b]	7 (1-10)	3 (1-6)	.01
Delirium-free[b]	9 (5-11)	7 (5-10)	.09
Coma-free[b]	10 (9-12)	8 (5-10)	<.001
Delirium	2.5 (1-5)	4 (1-5)	.71
Coma	2 (0-3)	3 (2-5)	.003
Prevalence of brain organ dysfunction, No. (%)[c]			
Delirium or coma	45 (87)	50 (98)	.03
Delirium	41 (79)	42 (82)	.65
Coma	33 (63)	47 (92)	<.001
Other clinical outcomes			
Mechanical ventilator-free, d[d]	22 (0-24)	18 (0-23)	.22
Intensive care unit length of stay, d	7.5 (5-19)	9 (6-15)	.92
28-Day mortality, No. (%)	9 (17)	14 (27)	.18

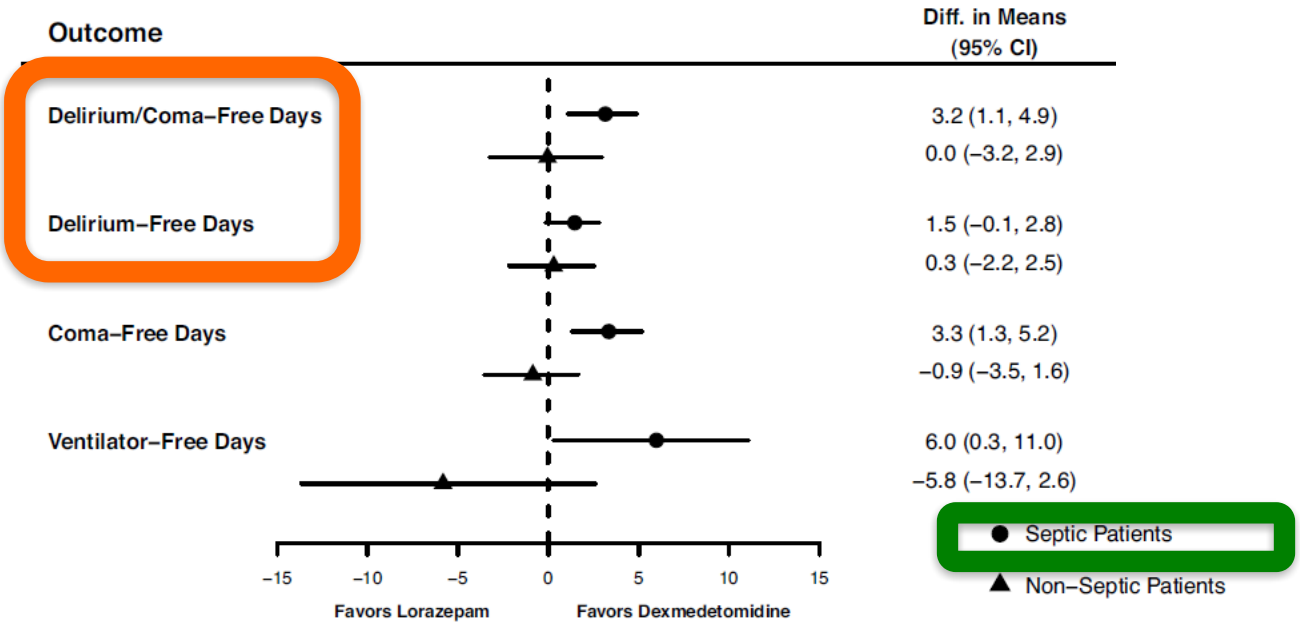
[a]Median (interquartile range) unless otherwise noted.
[b]Indicates the number of days alive without stated dysfunction from study days 1 to 12.
[c]Prevalence is used to describe the rates of brain organ dysfunction instead of incidence because preintensive care unit delirium or coma status could not be determined. Prevalence represents the occurrence of brain organ dysfunction at any time during the 12-day assessment period.
[d]Indicates the number of days alive, breathing without mechanical ventilator assistance, from study day 1 to 28.

Figure 2. Delirium-Free and Coma-Free Days During Study



JAMA 2009

Effect of dexmedetomidine versus lorazepam on outcome in patients with sepsis: an *a priori*-designed analysis of the MENDS randomized controlled trial



Pandharipande *et al. Critical Care* 2010, **14**:R38

JL Stollings, Ann Pharmacotherapy

ORIGINAL

Potentially modifiable factors contributing to sepsis-associated encephalopathy

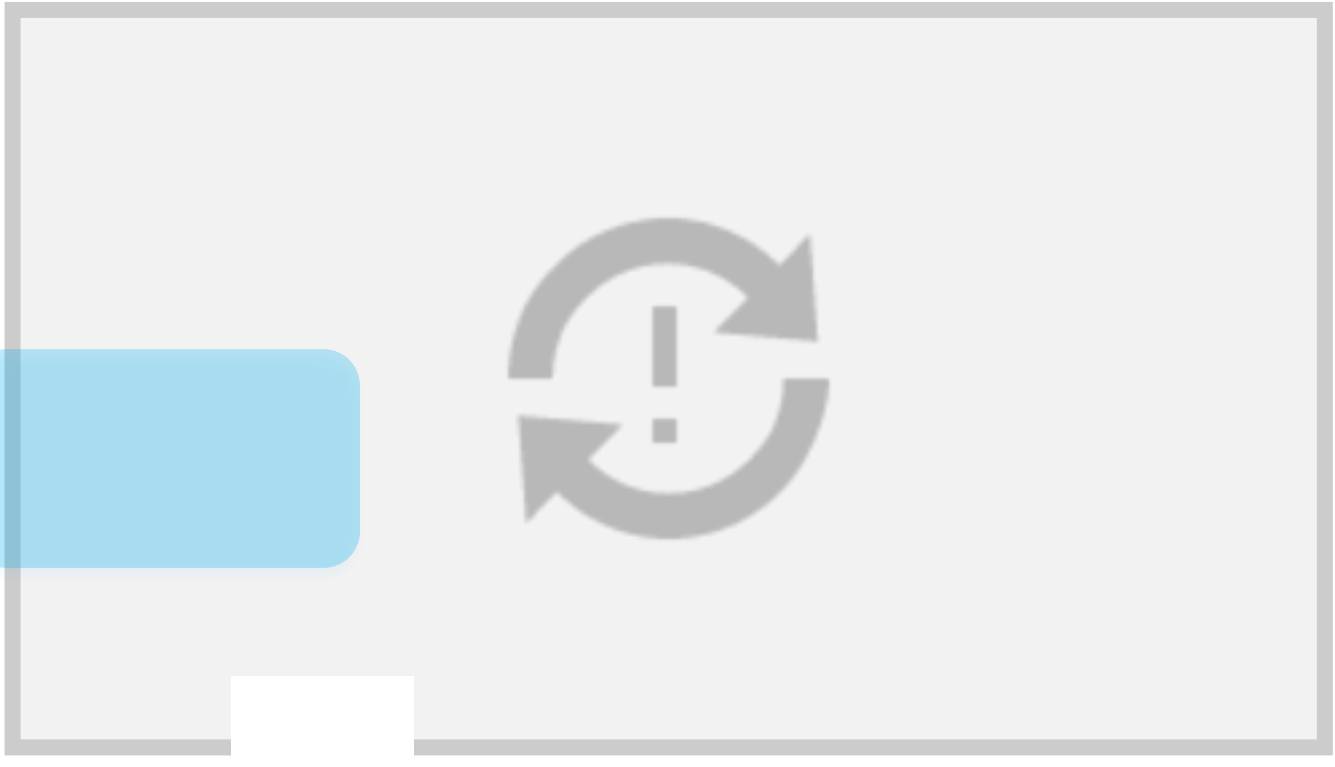
Romain Sonneville[1,2*], Etienne de Montmollin[3,4], Julien Poujade[1], Maité Garrouste-Orgeas[2,5], Bertrand Souweine[6], Michael Darmon[3,4], Eric Mariotte[7], Laurent Argaud[8,9], François Barbier[10], Dany Goldgran-Toledano[11], Guillaume Marcotte[12], Anne Sylvie Dumenil[13], Sami Ruckly[1], Guillaume Lacave[14], Stéphane Ruckly[2], Bruno Mourvillier[1,3] and Jean-François Timsit[1,3]

Risk factors for sepsis-associated encephalopathy, multivariate analysis

Variable	OR	95% CI		*p* value
Age, per 1-year increment	1.02	1.01	1.02	<0.01
Chronic alcohol abuse	3.38	2.34	4.89	<0.01
History of neurological disease	1.56	1.18	2.06	<0.01
Pre-existing cognitive impairment	2.25	1.09	4.67	0.03
Long-term use of psychoactive drugs	1.37	1.11	1.70	<0.01
Medical admission[a]	1.75	1.43	2.14	<0.01
Renal SOFA > 2	1.41	1.19	1.67	<0.01
Hypoglycemia, <3 mmol/l	2.66	1.27	5.59	<0.01
Hyperglycemia, >10 mmol/l	1.37	1.09	1.72	<0.01
Hypercapnia, >45 mmHg	1.91	1.53	2.38	<0.01
Hypernatremia, >145 mmol/l	2.30	1.48	3.57	<0.01

Intensive Care Medicine 2017

Bhattacharyya S, Neurology 2016



Bhattacharyya S, Neurology 2016

Hospital Critical Care 2019; 23:364
https://doi.org/10.1186/s13054-019-2659-7

CRITICAL CARE

RESEARCH Open Access

Cefepime neurotoxicity in the intensive care unit: a cause of severe, underappreciated encephalopathy

Jennifer E Payne[1], Ijaz A Kalimullah[2], Sara E Nickel[1], Sarah L Clark[3], Dekota W Wijdicks[1] and Alejandro A Rabinstein[1*]

Annals of Intensive Care

RESEARCH Open Access

Systematic overdosing of oxa- and cloxacillin in severe infections treated in ICU: risk factors and side effects

Mathilde Kerneis[1], Najoua El Helali[1], Eric Magdeleine[1], Agnès Lacroix[1], Richard Verdier[1], Jean-François Soubirou[1], Guillaume Monet[1], Alexandre Mamzer[1], Stéphane Ruckly[2], Lila Bouadma[1,2], Romain Sonneville[1], Jean-François Timsit[1,2] and Bruno Mourvillier[1,2]

Brain dysfunction in sepsis

- Definitions
- Risk factors and outcomes
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- Conclusion

Conclusions

- **Neurological dysfunction** is observed in **50% of patients with sepsis**
- **Brain dysfunction** is a **strong predictor of poor outcome**
- **A Multimodal non invasive monitoring is feasible in septic patients**
  - Clinical examination with appropriate tools
  - EEG : background changes, reactivity
  - Brain MRI for selected patients : white matter abnormalities, ischemia
- **Evaluation of confounders is critical for appropriate neurological evaluation**
  - Renal failure and metabolic disturbances
  - Antibiotic neurotoxicity
  - Sedatives

PIC 2018

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Update in Neurocritical Care

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