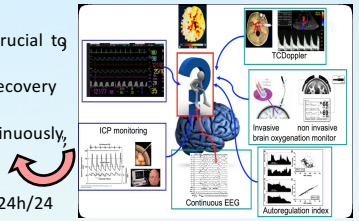
Computerized Classification of Brain Pathophysiological Status after Severe Traumatic Brain Injury

N. Savy[1], S. Fartoumi[2], F. Bernard[3], H. Assaf[2], M. Sawan[2] and G. Emeriaud[1]

[1] Pediatric Intensive Care Unit, CHU Sainte-Justine, Université de Montréal, Montreal, Quebec, Canada; [2] Polystim Neurotechnology Laboratory, Department of Electrical Engineering, Polytechnique Montreal, Quebec, Canada; [3] Intensive Care Unit, Hôpital Sacré-Coeur, Montreal, Quebec, Canada

Introduction :

- Precise assessment of brain condition after severe traumatic brain injury (TBI) is crucial to reduce secondary injuries and sequelae.
- Management guidelines are inconsistently followed, leading to decreased chances of recovery
- Computerized Decision Support Systems (CDSS) can assist clinicians in optimizing care :
  - Data of multimodal neuromonitoring are complex to interpret continuously, especially in the overwhelmed environment of intensive care unit (ICU)
  - Clinical conditions in TBI are compounded and evolve rapidly.
  - It should help the clinicians to react faster and to follow recommendations 24h/24



This study aims to evaluate an algorithm for classifying the cerebral conditions, as a first step in the development of a CDSS.

Results :

- Nine recording periods (median duration 4,7 hours, range 2-8 hours, 44 hours in total) from 4 adults (mean age) with severe TBI were analyzed.
- The pathophysiological status was appropriately classified by the CDSS in 93 % (interquartile: 91-97%) of time for all the recordings (as illustrated in an example in Figure 2).
- Every critical event was detected, but brief misclassifications were observed during the transition periods.
- Our algorithm compared to different classification methods (Table 1)
- Diagnosis accuracy high regardless the recording duration (Table 2)

Recording	Length (hours)	Diagnosis accuracy (%) GDCFMMN
1	2.5	97
2	2	99
3	2	98
4	8	95
5	4.7	92
6	3.9	99
7	4.9	100
8	8.2	97
9	7.9	99

Table 2: Diagnosis accuracy of the GDCFMMN for each recordings

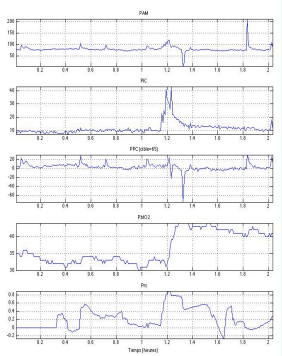


Figure 2a: Example of one of the data collections

Algorithms	State 1		State 2		State 3		State 4		State 5		State 6	
	Sens.	Spec.	Sens.	Spec.	Sens.	Spec.	Sens.	Spec.	Sens.	Spec.	Sens.	Spec.
DCFMMN	78	32	72	95	67	98	0	1	8	93	82	93
GDCFMM	99	91	69	99	83	1	29	1	90	99	90	99,9

Table 1 : Sensitivity and specificity of the different classification algorithms for each cerebral states

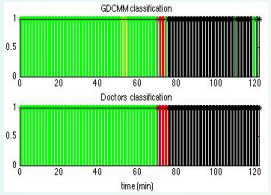


Figure 2b: Accuracy between CDSS classification and doctors'

Methodology :

- Retrospective analysis of a clinical electronic database, approved by the local Research Ethics Committee.
- Patients with **severe TBI** (Glasgow coma scale score < 8) with **monitoring of intracranial pressure and brain tissue oxygenation pressure** were eligible.

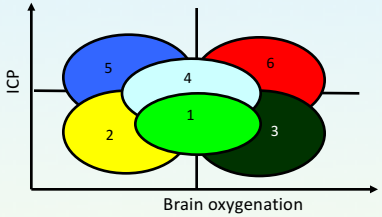


Figure 1 : Different cerebral status categories schema

- Data were extracted from the existing ICU electronical medical records (sample periods of 30 sec) (Semi Solutions Médicales).
- An **incremental learning fuzzy min-max neural networks** (FMMNs) classifier that adjusts its parameters online was implemented.
- The **different cerebral status** categories included: controled condition (1), ischemia (2) or hyperemia (3) without intracranial hypertension (ICHT), moderate ICHT with controlled brain oxygenation (4), ICHT with ischemia (5) or hyperemia (6) (Figure 1)
- Previously validated and published datasets were used to train the system. The system was then tested with the patients data and the output was compared to diagnosies obtained by consensus of two clinical experts (« gold standard »)

Conclusion :

In this preliminary cohort of patients with severe TBI, the **CDSS was able to adequately classify the brain condition in a large proportion of time**, but some errors occurred during brief transitional periods. Further training of the CDSS with a larger dataset may improve the system accuracy, which should be tested in a larger patient population.

Acknowledgement :
Patient illustrative data were provided by F. Bernard (Neuro-ICU, Sacré Coeur Hospital of Montreal), with the help of Semi Solutions Médicales. This research project is supported by the Centre d'excellence en traumatologie pédiatrique du CHU Sainte-Justine, the Fondation neurotrauma Marie Robert, and the Consortium pour la recherche en traumatologie du Fonds de recherche du Québec-Santé.