15th World Congress on Brain Injury
March, 2025

Motor Dysfunction in Prolonged Disorders of Consciousness

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GIGA-Consciousness, University of Liege
NeuroRehab & Consciousness Clinic
University Hospital of Liege

Disclosures

- Nothing to disclose

Learning objectives

- Review the characteristics and impact of the main motor disorders – spastic paresis – in patients with prolonged DoC

Specificities of DoC patients

- **Absence of communication**
- Lack of interaction with environment
- Severe motor disability (e.g., spasticity)
- Constantly bedridden
- Fatigability
- Aphasia, blindness, deafness, …

« Hable con Ella »
Pedro Almodóvar

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➔ No active rehabilitation strategies

Interventions

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Class	Pharmacologic	Electromagnetic	Mechanical	Sensory	Regenerative
Best evidence	RCT (amantadine)	RCT (tDCS, TMS)	Case series	RCT (auditory)	Phase 1 trials (stem cells)
Efficacy	Faster rate of recovery	Improvement 30-50% MCS patients (frontal tDCS)	Improvement in 1/1 acute & 2/3 chronic patients	Behavioral + fMRI improvements	Possibly faster recovery
Safety	+	DBS – tDCS, TMS, taVNS: ++	++	Tactile, auditory: +++ Vestibular: ++	Unknown
Limits	Delayed action, drug tolerance, transient effects	DBS: invasive tDCS, TMS, taVNS: moderate transient effects	Early development	Tactile, auditory: uncertain effects, Vestibular: early development	Early development
Ongoing trials	4	10	1	5	0

Edlow, Sanz* et al., 2021*

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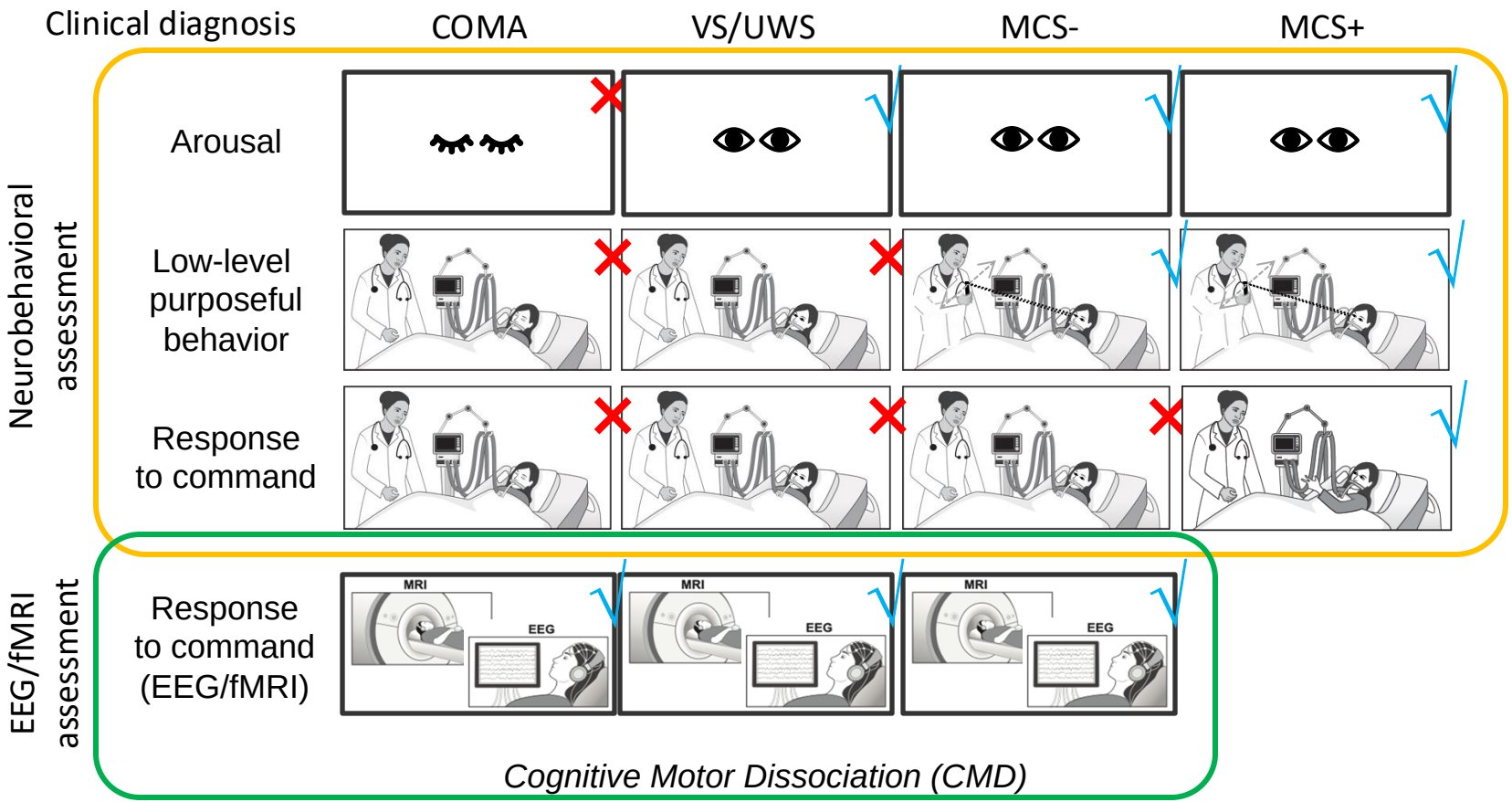
Edlow, Sanz* et al., 2021*

➔ More research aiming to promote **motor recovery**

Cognitive Motor Dissociation



Claassen et al. Neurocrit. Care, 2023, Bodien et al. NEJM, 2024

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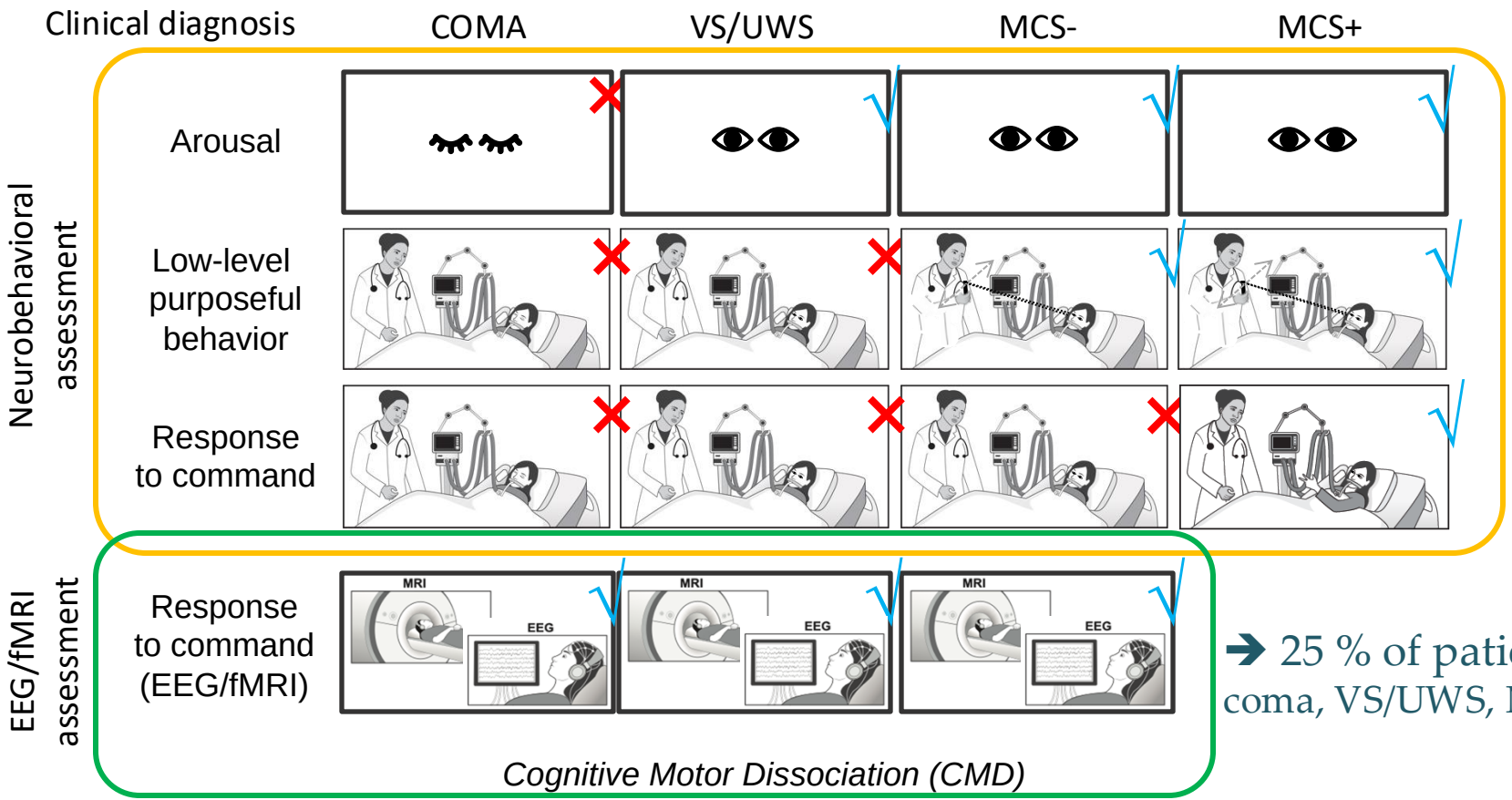

➔ 25 % of patients
coma, VS/UWS, MCS-

Claassen et al. Neurocrit. Care, 2023, Bodien et al. NEJM, 2024

Spasticity definition

➔ Involuntary velocity-dependent increase in muscle tone or tonic stretch reflexes associated with hypertonia (Lance, 1990)

Aggravating factors: Velocity of stretching
Fatigue & stress
Infection & pain

Side effects: Muscle retraction (↘ sarcomeres)
Irreversible stiffness of joints
Vicious positions & pain
Sign of consciousness

Baude, Nielsen, Gracies JM. AP&RM 2019

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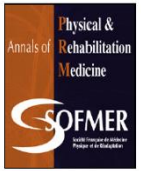
Immobilization: ↗ side-effects

Baude, Nielsen, Gracies JM. AP&RM 2019

Spastic parasis



Two main components

Annals of Physical and Rehabilitation Medicine 62 (2019) 426–430

The neurophysiology of deforming spastic paresis: A revised taxonomy

Marjolaine Baude [a,*], Jens Bo Nielsen [b], Jean-Michel Gracies [a]

1. Neurological disorder

A. Spastic over-activity

- Spasticity : velocity-dependent hyperactive stretch reflexes
- Spastic dystonia : involuntary muscle activation at rest
- Spastic co-contraction : simultaneous activation of antagonist and agonist

B. Stretch-sensitive paresis : reduced central command to agonist muscles

➔ A&B impairing voluntary movement

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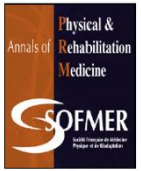

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2. Muscular disorder **spastic myopathy**

Arises due to prolonged immobilization, leading to muscular stiffness

➔ impairing voluntary movement

➔ partially preventable with proper care

Baude, Nielsen, Gracies JM. AP&RM 2019

Spastic paresis in DoC

Both components impact movement & immobilization
Spastic paresis limits voluntary movement, increasing immobilization & exacerbates muscle dysfunction
➔ muscular and neurological disorders interact, worsening clinical symptoms

Baude, Nielsen, Gracies JM. AP&RM 2019
Martens et al., 2017; Zhang et al., 2021
Thibaut et al. NeuroRehab. 2024

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DoC patients : spastic paresis prevalence is extremely high (57–95%)
& DoC patients are mostly immobile which may worsen spastic paresis
➔ leading to muscle atrophy, joint contractures & exacerbate their inability to demonstrate signs of consciousness

Spastic paresis >< spasticity

Baude, Nielsen, Gracies JM. AP&RM 2019
Martens et al., 2017; Zhang et al., 2021
Thibaut et al. NeuroRehab. 2024

Spastic paresis, pain & PT

Prevalence (n=65): 88% (n=59) suffered from spasticity (MAS≥1) and 60% (n=39) suffered from severe spasticity (MAS≥3)

Thibaut, Chatelle, et al., Eur J of Rehab & Phys Med, 2014, Thibaut *et al.*, NeuroRehabilitation, 2018

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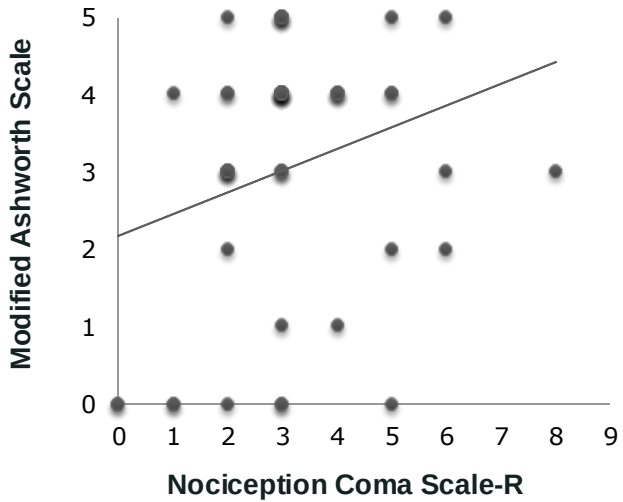
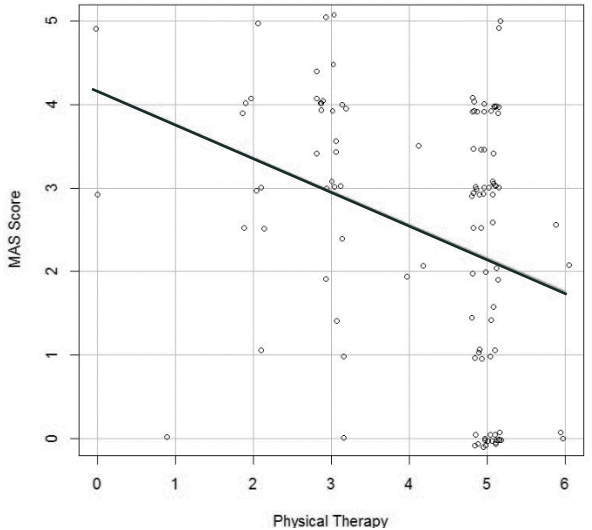


N=65

↗ with pain



N=109

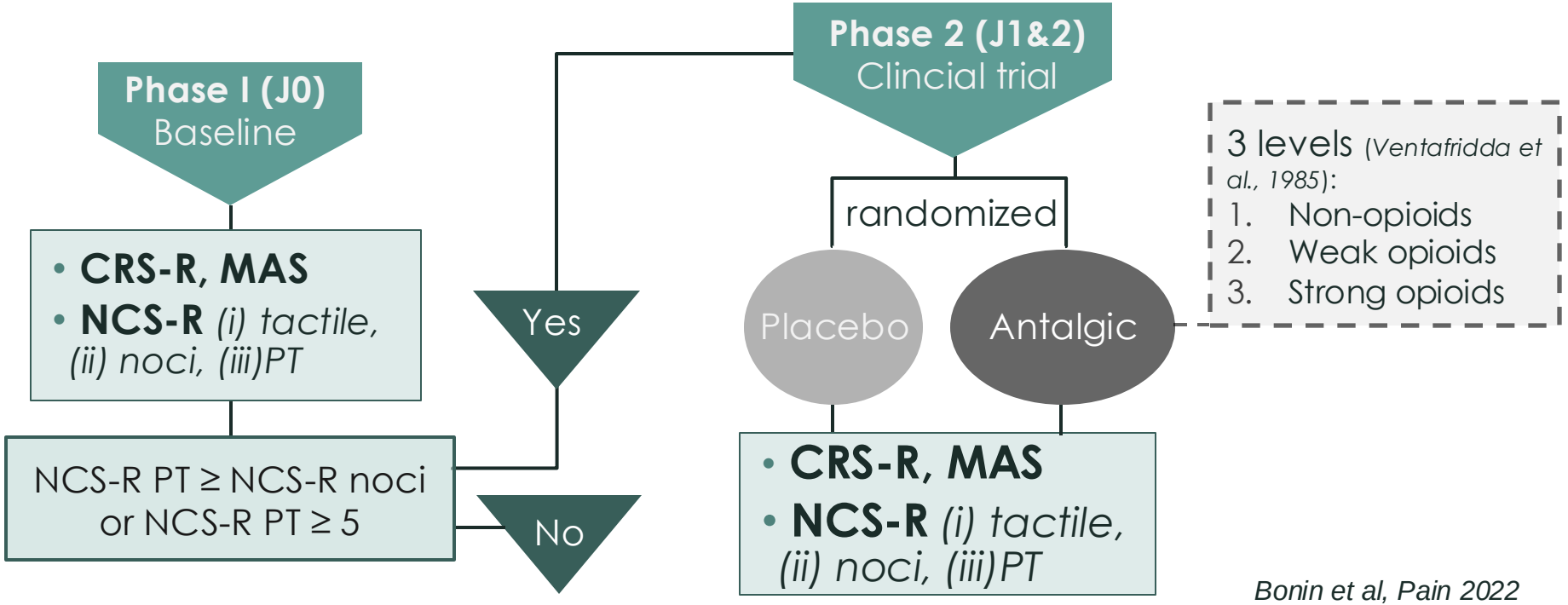
↘ with PT

Thibaut, Chatelle, et al., Eur J of Rehab & Phys Med, 2014, Thibaut *et al.*, NeuroRehabilitation, 2018

PT & pain in DoC

2-phases clinical trial to

- Evaluate prevalence pain during PT
- Evaluate effects of antalgic on NCS-R scores (rest & during PT)

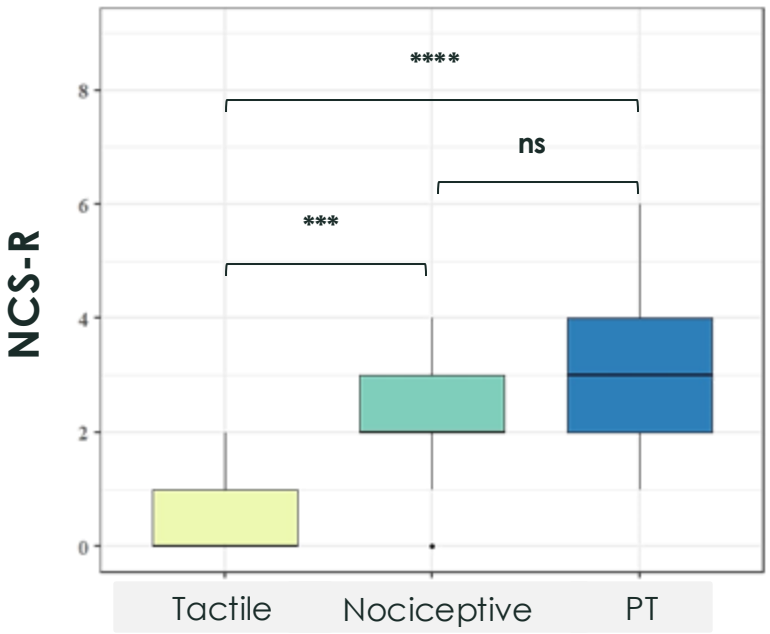


Bonin et al, Pain 2022

PT & pain in DoC

Population: N = 18, 9 F, 14 MCS, 5 TBI, 44±15 y

Phase I



Kruskal-Wallis and Dunn tests
ns = non significatif, *** = p < 0.001, **** = p < 0 .0001

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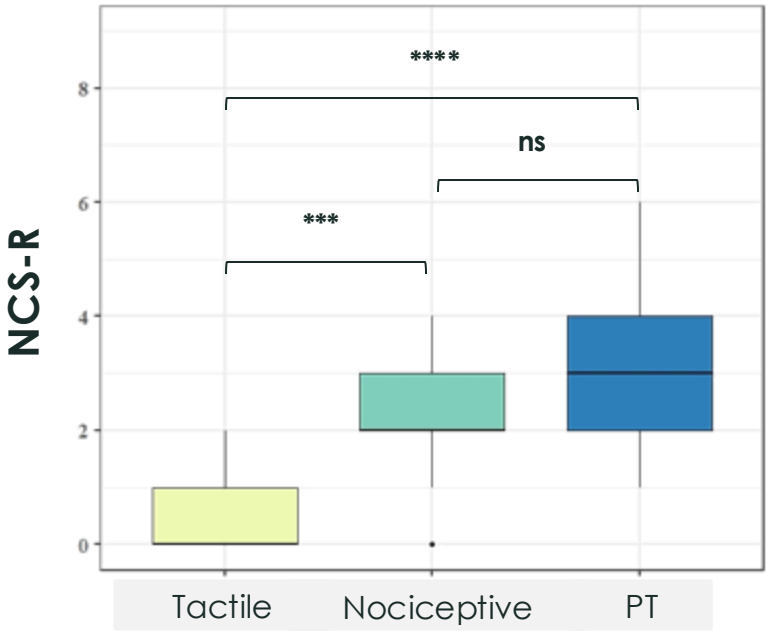

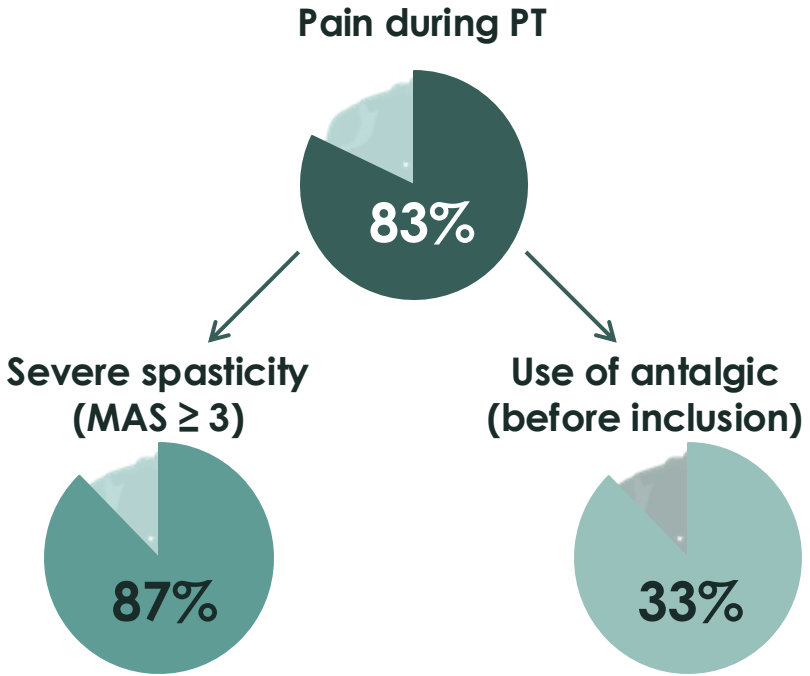

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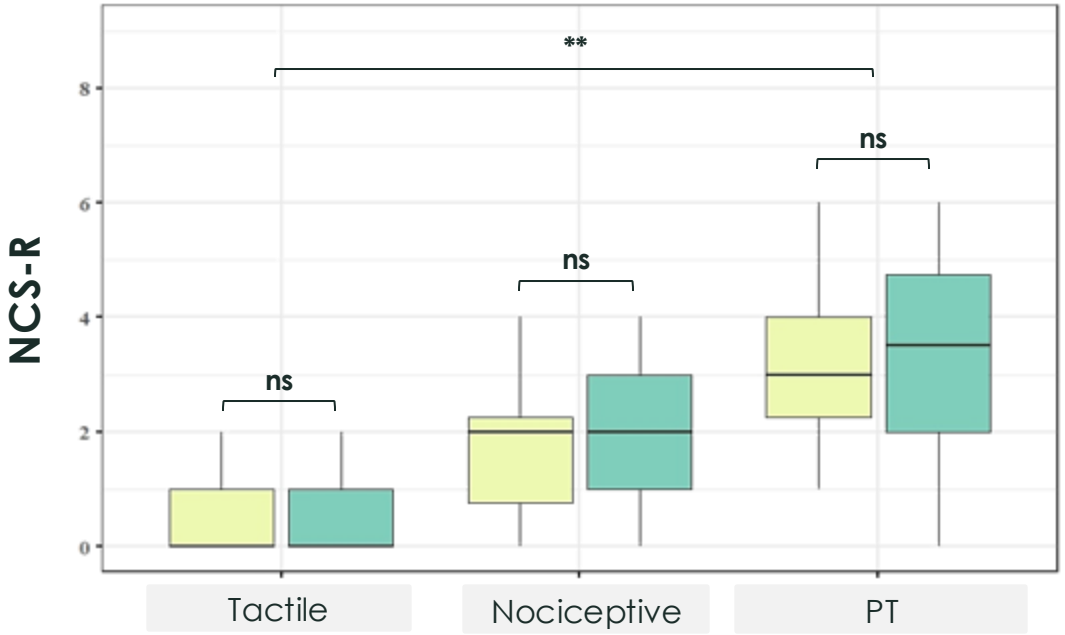
Bonin et al, Pain 2022

PT & pain in DoC

Randomized clinical trial in 10 patients (3 F, 45±3 years old, 8 MCS, 5 TBI)



Placebo

Antalgic

➔ **No effect** on NCS-R scores

ns = non significatif, ** = p < 0.01

Bonin et al, Pain 2022

Spastic paresis prevalence & management

Large longitudinal study of 146 prolonged DoC in rehabilitation center

➔ **95.2% DoC were spastic** & 52.7% all four limbs

- Most commonly affected muscle groups => shoulder internal rotators (72.6%) & ankle plantar flexors (59.8%)
- 70% received chemoneurolytic injections (botulinum toxin and/or phenol) & 26.7% intrathecal baclofen pump
- Focal managements => reduced systemic antispastic medications (eg, baclofen) > 50.0%

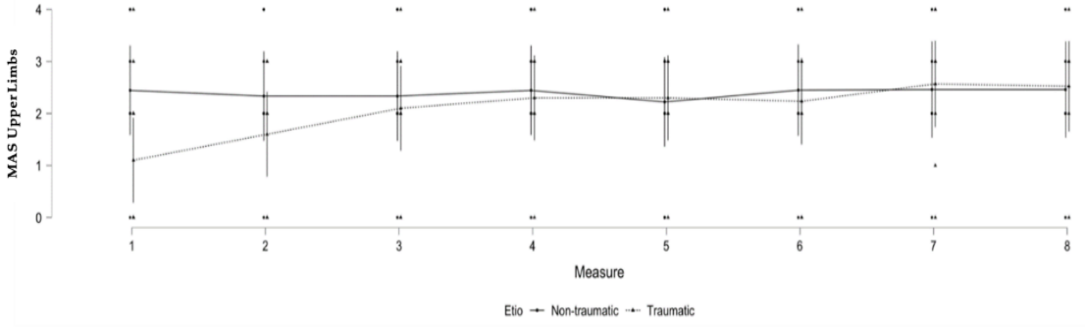
  ➔ improvements in consciousness

Zhang et al, PM&R 2021

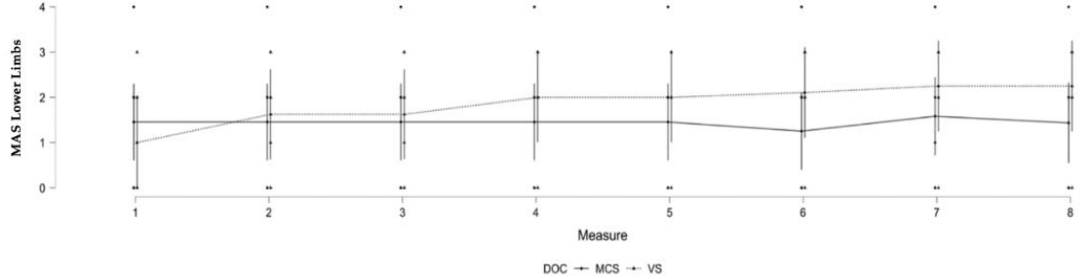
Evolution of spastic paresis

Prospective longitudinal (2 years) study in 19 prolonged DoC in rehab

TBI vs NTBI



MCS vs VS/UWS



➔ underlying brain lesions & level of csc might impact spasticity over time

Winters et al., Brain Sci 2022

Prevalence & predictors of spastic paresis

DOCTOR study - follow-up (Driessen et al. BMC Neurol 2021)

Assess prevalence & predictors of spasticity in prolonged DoC patients early intensive neurorehabilitation program

Draulans et al, in prep

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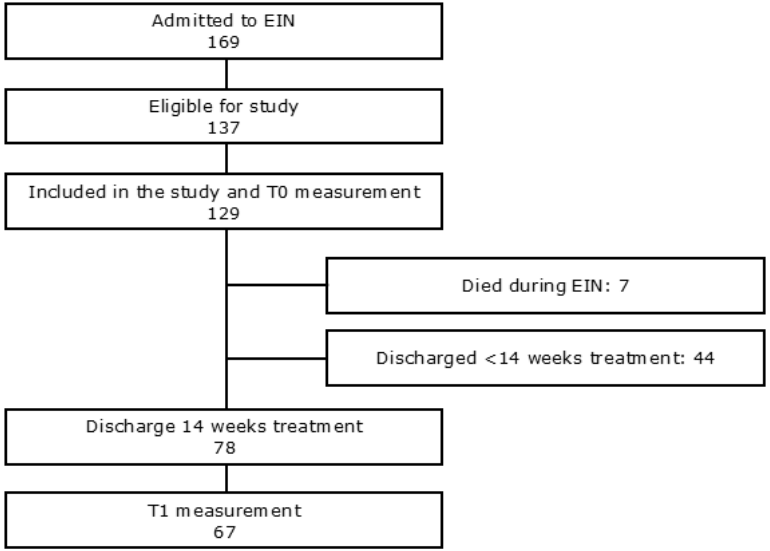
Assess prevalence & predictors of spasticity in prolonged DoC patients early intensive neurorehabilitation program

Prospective, single center study

129 DOC : 38.3±16.3yo, 62wo (48%), 48 UWS/VS (37%), 72 TBI (56%), 72±29d post-injury.

14 weeks rehabilitation program

CRS-R, AS, NCS at admission & discharge



Draulans et al, in prep

Prevalence & predictors of spastic paresis

Admission:

- 88% DoC presented spasticity (AS ≥1) at admission
- Distribution pattern throughout different muscle groups was widespread

Draulans et al, in prep

Prevalence & predictors of spastic paresis

Admission:

- 88% DoC presented spasticity (AS ≥1) at admission
- Distribution pattern throughout different muscle groups was widespread

- No association was found between spasticity &
  - age
  - time since injury
  - diagnosis
  - etiology

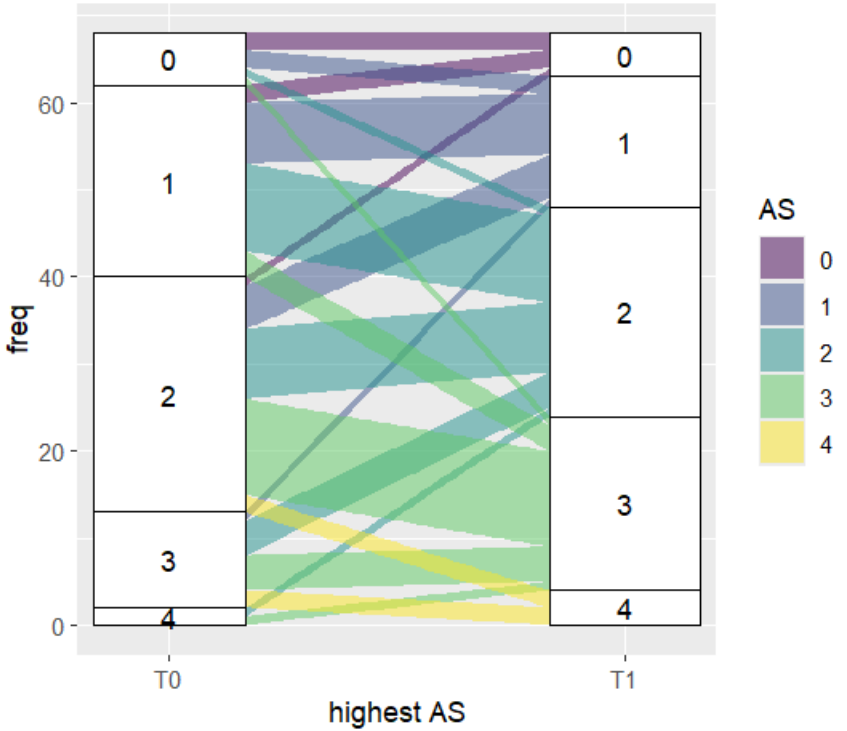
Draulans et al, in prep

Prevalence & predictors of spastic paresis

Discharge:

- Prevalence (≥1 muscle) of spasticity increased from 88 to 93%
- Spasticity worsen in 46% patients

Evolution of highest MAS admission & 14-week rehab



Draulans et al, in prep

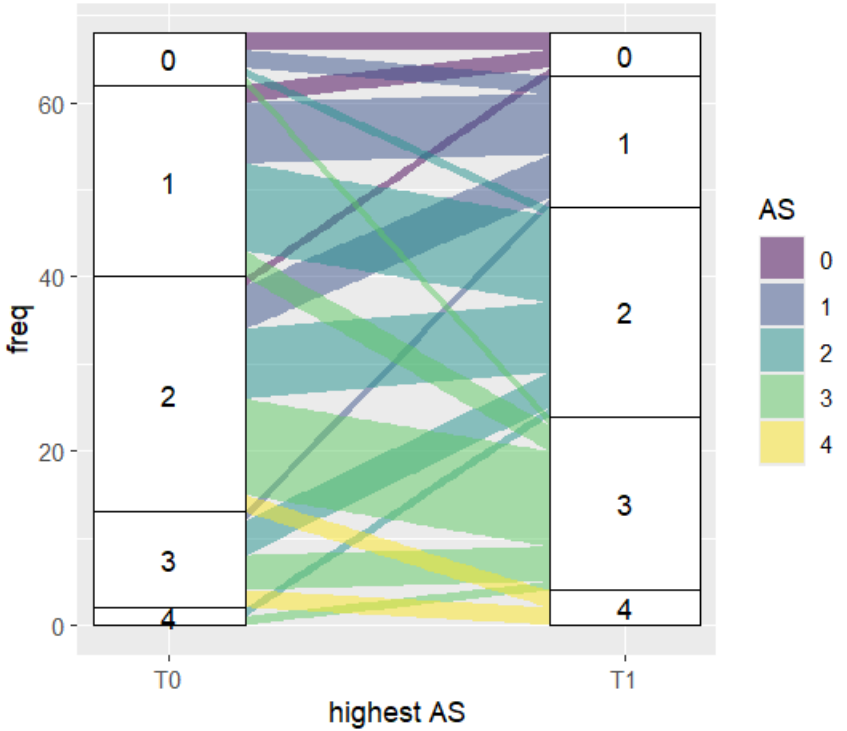
Prevalence & predictors of spastic paresis

Discharge:

- Prevalence (≥1 muscle) of spasticity increased from 88 to 93%
- Spasticity worsen in 46% patients

- Predictors for progression to severe spasticity (MAS ≥3):
  - greater number of muscles with spasticity at admission
  - non-TBI etiologies

Evolution of highest MAS admission & 14-week rehab

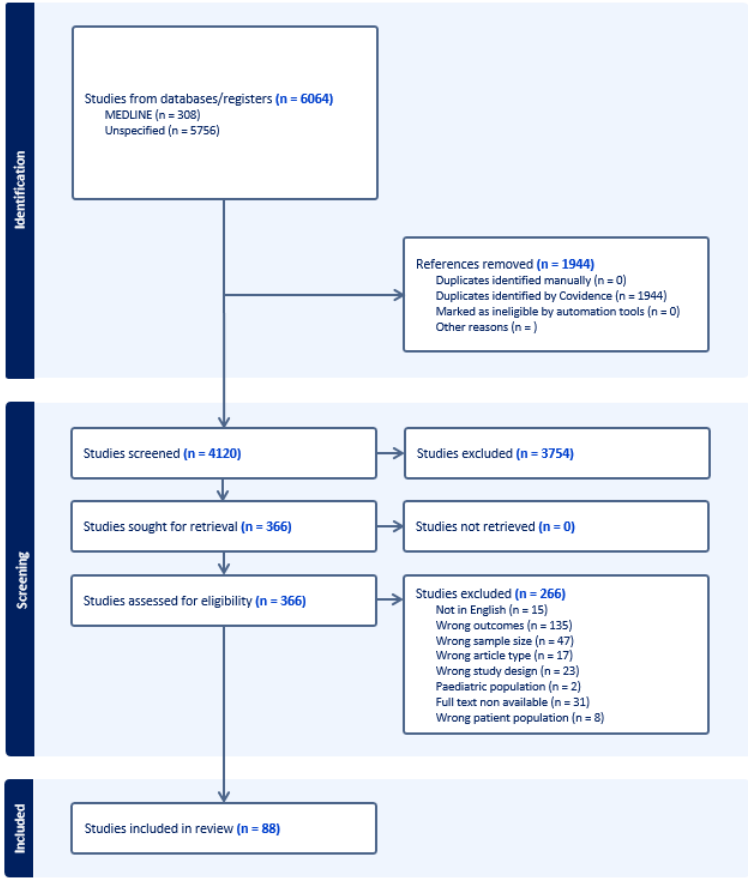


Draulans et al, in prep

Spasticity in non-DoC stroke, TBI, anoxia

Scoping review to investigate the prevalence of spasticity and – when possible – different spasticity related components (e.g, hypertonia, spastic dystonia, spastic myopathy, spastic co-contractions) in "non-DoC" populations (i.e., TBI, stroke and anoxic brain injury)

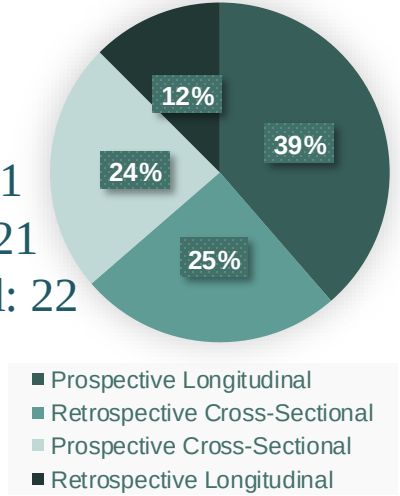
Total number of studies for data extraction = 88



Spasticity in non-DoC stroke, TBI, anoxia

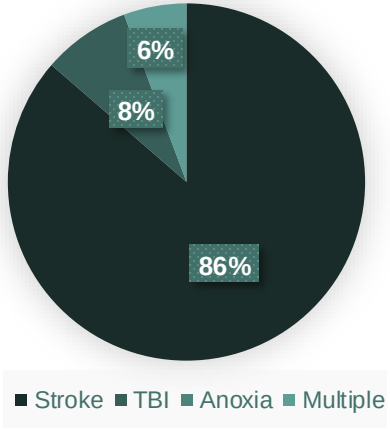
Study design

- Prospective longitudinal: 34
- Retrospective longitudinal: 11
- Prospective cross-sectional: 21
- Retrospective cross-sectional: 22



Etiology

- Stroke: 76
- TBI: 7
- Anoxia: 0
- Multiple: 5



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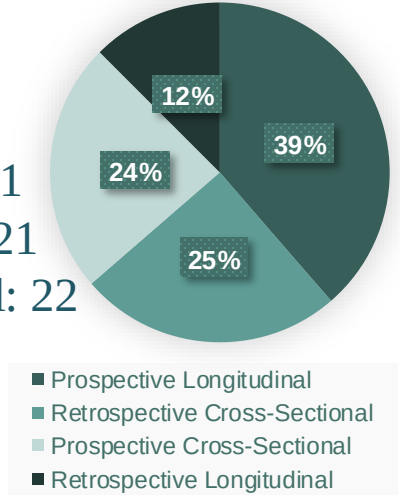

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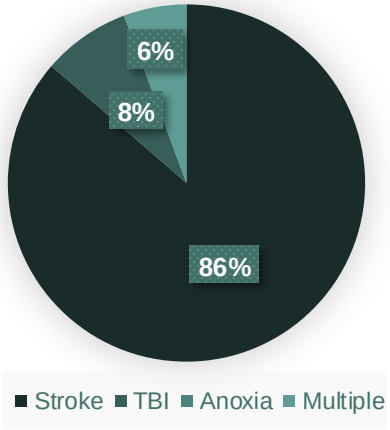


Spasticity measures

- MAS: 55
- MTS: 7
- Other scales: 11

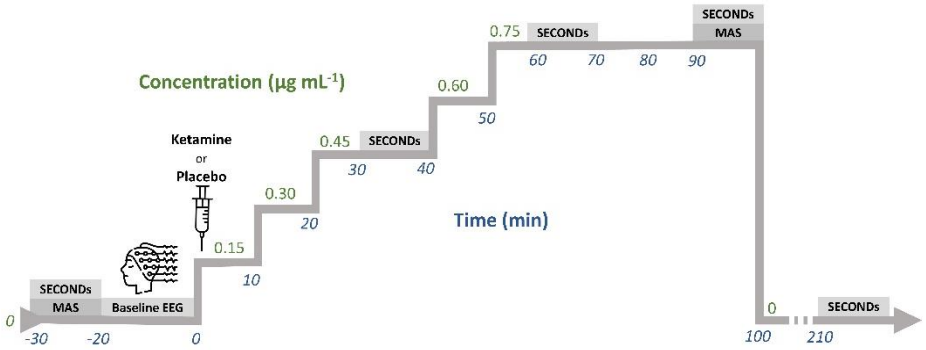
Prevalence of spasticity (n=47 – 53%)

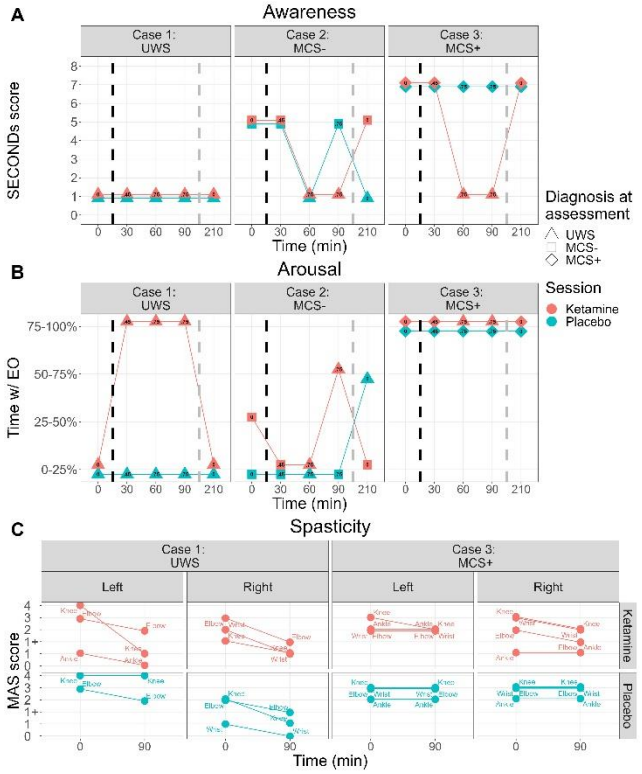
- Overall ➔ 44 %
- Stroke ➔ 43%
- TBI ➔ 60%
- Anoxia /

Serendipitous effects of ketamine

Reduction of spasticity following ketamine injection in DoC

Sub-anesthetic injection of ketamine in 3 pts





1 UWS, 1 MCS-, 1 MCS+
SECONDs, EEG, MAS (2 pts)

Symposium Thursday 3.30-5 pm
Dr Gosseries

Cardone et al. iScience 2024

Conclusion

- **Spasticity is extremely frequent** in DoC & correlates with pain
- **Spasticity increases** despite rehabilitation & ≠ etiologies
- **Management:**

  Daily PT sessions are recommended but PT might be painful

  Multidisciplinary approach (pharma & rehab)

  Serendipitous discoveries ?

➔ **Need to improve management of spasticity in DoC for patient's comfort/pain & express signs of consciousness – CMD**

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CLINIQUE DE LA CONSCIENCE ET DE NEUROREVALIDATION

Thank you !

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