

Research article

Progressively complex neurorehabilitation: from a severe coma to a vegetative state, minimal consciousness ... *and the Phoenix bird survives and is reborn from its ashes*

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Abstract: Romania has the highest rate of car accidents and deaths per million inhabitants in the European Union, primarily due to poor driving and substandard road conditions. Victims of car accidents often present with complex medical cases involving multiple injuries across various organs, frequently leading to severe complications. Case report. With the approval of the patient's family and the Ethics Committee (no. 19348/25.04.2024) at the Neuromuscular Rehabilitation Clinic, Emergency Hospital "Bagdasar-Arseni," a case study was conducted. A 22-year-old man without a previous medical history suffered severe polytrauma as a result of a road accident. He was transferred to the Neuromuscular Rehabilitation Clinic in a vegetative state (after multiple fractures of the skull base and visceral cranium, with 3 points GCS), atlantoaxial subluxation (requiring cervical collar immobilization), rib fractures, drained hemothorax, near-complete atelectasis of the left lung, status post-pericardial effusion. The medical intervention involved a multifaceted pharmacological approach. Focal intramuscular injections of botulinum toxin targeted specific muscles significantly alleviated spasticity. Special robotic orthoses were used to correct postural abnormalities and maintain the favorable effects of the botulinum toxin. The patient received a personalized and complex nursing rehabilitation program including tracheal stoma management, nutritional support through IV infusions and percutaneous gastrostomy (PEG) feeding, re-education of deglutition, intermittent urinary catheterization, and positioning on a special mattress to prevent pressure ulcers. The kinesiotherapy was progressively adapted to the neurologic and general condition. The patient had slight improvements in motor and cognitive abilities, resulting in simple voluntary gestures and affective response schemes. In time, he progressed to a minimally conscious state; he responded to verbal stimuli through blinking and reactive adequate affective mimic in the context of persistent expressive aphasia. He was safely discharged at home. Our main functional objective is the patient's reinsertion into his family. Ad vitam prognosis and ad functionem outcomes are guarded. Ad laborem prognosis is nil. The patient was periodically reassessed for further rehabilitative care. This case emphasizes the importance of a complex multidisciplinary and patient-centered approach in managing post-traumatic vegetative status following a road traffic accident. The Phoenix symbolically takes steps toward fulfilling its destiny - to survive and gradually rise from its ashes.

Keywords: vegetative state; spasticity; tetraparesis; traumatic brain injury; botulinum toxin; neurorehabilitation

1. Introduction

According to the Association of Victims of Road Crashes, AVAC, there were 9,213 road accidents last year, causing more than 2,300 fatalities and resulting in around 8,500

severely injured people. Notably, car occupants accounted for 3,438 of the seriously wounded individuals between 2017 and 2019, reflecting a 3% increase from the 2010-2012 period [1].

Polytrauma patients present highly complex cases characterized by multilevel injuries and associated complications [2].

Traumatic brain injury (TBI), a significant public health issue, can result in varying degrees of disability and underscores the importance of addressing road traffic injuries as a leading cause of unintentional, preventable harm [3,4].

Persistent vegetative status (PVS) or unresponsive wakefulness syndrome (UWS) represents a complex and challenging medical condition arising mainly after a TBI and requiring a comprehensive and multidisciplinary approach [4,5]. Individuals in this state display no self-awareness, cannot interact with their surroundings, may resume the sleep-wake cycle, and open their eyes spontaneously or under stimulation. Notwithstanding these deficiencies, certain fundamental brain functions, such as those associated with the autonomic nervous system and the hypothalamus, may persist to some degree [5–7].

Effective management of PVS/UWS demands an interdisciplinary approach involving costly medical rehabilitation programs [8].

If PVS persists for more than 12 months after the traumatic injury, it is considered to be permanent, so this timeframe is essential for nosological classification [4,5,9].

Sometimes it is possible to improve to a minimal level of consciousness or even beyond [7].

The medical approach addressing this condition typically involves a comprehensive rehabilitative nursing program and proactive measures, including appropriate nutritional support, prevention of infections, and an adapted kinesiotherapy program. Strategies such as employing passive robotic devices to assist kinesiotherapy and preserve optimal joint ROM and utilizing botulinum toxin to manage spasticity [4] are associated with kinetic therapy, enhancing functionality, facilitating recovery, improving quality of life, and providing support in care [2,10–12].

1. Case presentation

On the 8th of May 2024, the patient was admitted to the Intensive Care Unit (ICU) after:

1. Skull base fractures involving the occipital bone, temporal bones, mastoids, sphenoid bone, orbit walls, maxillary sinus, mandible, and clivus.
2. Atlantoaxial subluxation with secondary stenosis of the medullary canal, requiring cervical collar immobilization and neurosurgical observation.
3. Thoracic trauma with rib fractures, pleural effusion, and near-complete atelectasis of the left lung, treated with pleurectomy drainage.
4. Pericardial effusion predominantly on the left side.
5. Musculoskeletal and soft tissue trauma with right eyebrow laceration, ecchymosis, blepharoplasty and laceration of the second finger of the right hand

The patient received care in the ICU, where tracheostomy with cannulation and percutaneous gastrostomy (PEG) were performed.

Upon admission to our Clinical department, the patient displayed PVS/UWS, a severely modified general condition, but afebrile, cachexia, pallor, neurogenic bladder, indwelling urinary catheter, and multidrug-resistant *Proteus mirabilis* urinary infection, multiple scars and ecchymoses, and right calcaneal decubitus lesion.

The neuro-myo-arthro-kinetic (NMAK) examination revealed:

- The cervical spine was stabilized with a cervical collar.
- Spastic tetraplegia with amyotrophic and myo-tendon retractions, disabling deformities in the upper limbs, with quasi-irreducible flexion of the fingers and wrists; the feet exhibited a 120-degree equinovarus deformity.
- The right eye was surgically closed. The left one was opened, had uncoordinated eye movements, and the gaze did not track objects, with present pupillary reflex

- He exhibited body movements and grimaces in pain without localizing the noxious stimuli.

The patient was hemodynamically stable. The vesicular murmur was present bilaterally, slightly diminished on the left side, and rare bronchial rales were disseminated in the pulmonary bases. He breathed spontaneously via a cannula/tracheostomy and with an oxygen saturation of 96%, blood pressure of 90/50 mmHg, and heart rate of 88 bpm. The abdomen was supple, depressible, and mobile in conjunction with respiratory movements, with no evidence of peritoneal irritation. PEG was in situ with clean dressings. A permanent indwelling urinary catheter was in place, with clear, hyperchromic urine in the collection bag.

The patient was clinically and functionally periodically assessed, according to the standardized protocols implemented in our clinic using: AIS (American Spinal Injury Association Impairment Scale), Ashworth and Penn spasticity scales, FIM (Functional Independence Measure), FAC (Functional Ambulation Category), and GOS-E (Glasgow Outcome Scale – Extended). The types of scales and the scores that assessed the NMAK status at the first hospitalization in the neurorehabilitation clinic (in 2023) and at the last discharge are summarized in Table 1.

Scale	The first admission (August 2023)	The last discharge (June 2024)
FIM - cognitive	0/35	4/35
FIM - motor	0/91	3/91
Modified Ashworth scale	upper & lower limbs 2	upper & lower limbs 3
Spasm frequency (Penn)	1	2
FAC	0/5	0/5
GOS-E	2/8	3/8
Modified Rankin Scale	5/5	5/5
Barthel	0/100	0/100

Table 1: Clinical and functional scales used in quantifying the dynamic evaluation (at admission and last discharge)

The **paraclinical findings** indicated mild normochromic normocytic anemia (hemoglobin 11.2 g/d, mean corpuscular hemoglobin of 29.4 pg, and mean corpuscular hemoglobin concentration of 33.3 g/dL). Furthermore, mild hypoalbuminemia was present (3.2 g/dL). Additionally, the patient exhibited muscle cytolysis syndrome, as evidenced by elevated creatine kinase (CK) levels of 621 U/L and CK-MB levels of 123 U/L. The bronchial aspirate and urine culture have revealed the presence of multidrug-resistant (MDR) *Proteus mirabilis*.

A **brain CT scan** revealed hypodense sequelae (glial scars) in the right frontal-basal and temporal cerebral regions and white matter lacunae in the semioval centers, with no recent intra- or extra-axial hematomas. Additionally, there was a right frontal hygroma of 1.5 cm and non-displaced fractures at the base of the occiput and bilateral temporal regions with the involvement of the mastoids (fig.1 - A).

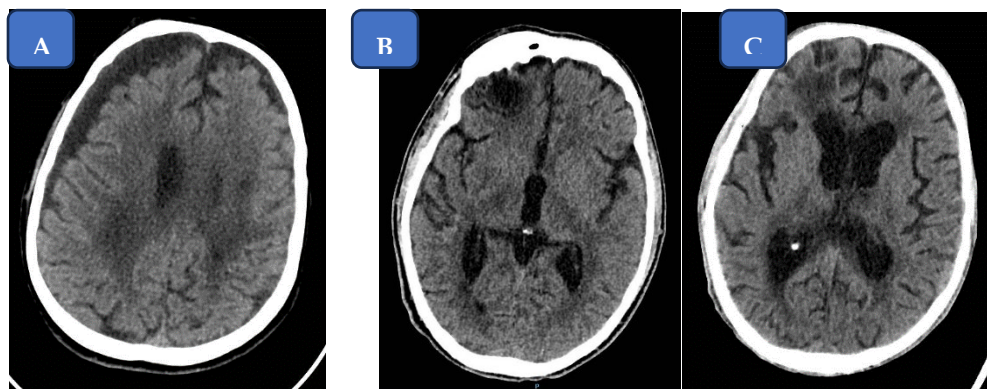


Figure 1 – Successive cerebral CT scans (A 09.08.2023 frontoparietal hygroma; B 20.11.2023 frontal hypodensity, post-concussive sequelae; C 12.06.2024). Frontoparietal hypoattenuating areas. The ventricular system displays slightly increased dimensions, with an Evans index of approximately 0.35, implying borderline ventricular enlargement; additionally, fine periventricular hypodensities indicate potential trans ependymal edema. Fig B and C: the mid-line structures showed no signs of deviation. Furthermore, there was a complete resolution of the right-sided subdural fluid accumulation.

Thoracic CT revealed organized alveolar pneumonia in the posterior segment of the left inferior lobe, bilateral pleural effusion measuring 35mm with near-complete atelectasis of the left lower lobe, mucoid impactions in the right main bronchus, and a fracture of the first and second ribs on the right side.

Initial bronchoscopy showed slightly diminished mobility of the vocal cords, a mildly congested mucosa, and a moderate quantity of diffusely mucous and mucopurulent secretions. A supra-stomal granuloma occupied 60% of the tracheal lumen. Decannulation was scheduled after 2-3 weeks.

Based on the clinical and paraclinical features, the diagnoses at the first admission to the Rehabilitation Clinic were:

1. **Unresponsive wakefulness syndrome** after severe polytrauma with TBI
2. Bilateral pleural effusion (35 mm) with near-complete atelectasis of the left lower lobe after drained hemothorax
3. Tracheal cannula/tracheostomy, with a supra-stomal granuloma occupying 60% of the tracheal lumen.
4. Organized alveolar pneumonia (posterior segment of the left inferior lobe) – with MDR *Proteus mirabilis*
5. Gastrostomy feeding (PEG)
6. Neurogenic bladder complicated with chronic urinary infections with MDR *Proteus mirabilis*

The complexity of the case necessitated the involvement of a multidisciplinary team comprising specialists in neurology, thoracic surgery, ophthalmology, and neurorehabilitation. The treatment was highly complex and imposed different approaches with complex and personalized nursing rehabilitation programs.

The rehabilitation nursing program addressed the underlying pathologies and consisted of practical measures: nursing, prevention of complications, improvement of the patient's psychological and cognitive well-being, and facilitation of the patient's reintegration into his family, ultimately enhancing their overall quality of life.

Comprehensive respiratory nursing care was provided, including assisted thoracic therapy to help clear pulmonary secretions and frequent mucus suctioning through the tracheal cannula (in the initial month) to prevent infection.

An incremental food habit re-education program was implemented based on the patient's specific needs. During the first 3 months, nutrition was achieved using PEG, subsequently transitioning to a combination of PEG nutrition and semi-solid oral intake. Emphasis was placed on ensuring safe swallowing and meeting complex nutritional requirements.

The transition from a permanent urinary catheter to an intermittent catheterization program was gradually introduced, with strict adherence to the aseptic technique. An anti-pressure mattress, periodic skin assessments, and repositioning techniques were implemented to prevent pressure ulcers.

We implemented a comprehensive strategy to improve the patient's psychological and cognitive well-being. This involved focusing on mental and emotional wellness through cognitive stimulation, with ongoing involvement from the medical team, speech therapist, psychologist, and family. The patient's family also received comprehensive education on disease management, caregiving techniques, and coping strategies to empower them to be proficient caregivers and improve overall patient outcomes.

The medical intervention consisted of a multifaceted pharmacological approach, encompassing prophylactic anticoagulation, mucolytics, antibiotics targeting MDR *Proteus mirabilis*, urinary antiseptics, gastroprotective and multimodal analgesic medication, a synergistic association of neurotrophic factors, antiepileptics, and antispastic drugs (up to 75 mg baclofen). The spastic muscles of the hands and legs were focally injected with botulinum neurotoxin type A (Figure 2).



Figure 2 – Severe spastic tetraparesis, quasi-irreducible flexion of the fingers and wrists. Focal injection with botulinum neurotoxin type A (June 2024)

Kinesiotherapy was mandatory to improve the patient's motor function, reduce spasticity, prevent permanent joint deformities, and enhance mobility and physical strength. Initially, the therapist provided bedside passive range of motion (ROM) mobilization and stretching using equipment like the MotoMed and specialized robotic dynamic orthoses to facilitate passive finger movement (Fig. 3). Additionally, pillows were used to position the joints and prevent retraction and uncomfortable positions.

The patient gradually achieved a seated posture with assistance and received physical therapy under the guidance of specialists.

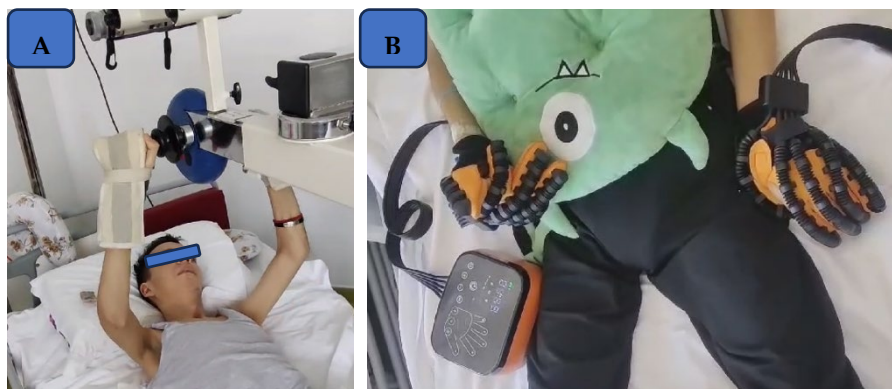


Figure 3 – Bedside Moto-Med and Sentinex rehabilitation robotic gloves (Halipax).

Evolution and outcomes:

After seven months of dedicated effort and support from the medical team and his family, the patient exhibited marginal but slowly progressive enhancements in both motor and cognitive functions.

The transition from a vegetative state to a minimally conscious state was documented. He demonstrated responsiveness to verbal stimuli by blinking and could fully open his eyes. Additionally, appropriate reactive affective mimicry and predominantly expressive aphasia were noted.

Ad vitam prognosis and *ad functionem* outcomes depend on adherence to long-term rehabilitative treatment, sustained psychological support, and avoiding further complications like pressure ulcers, aspiration pneumonia, and infections. *Ad laborem* prognosis is nil.

The recommendations at discharge include the following: strict adherence to the prescribed neuro-rehabilitation program as directed upon discharge, limited screen time (≥ 2 hours/24 hours) for bright screens such as television or tablet, personalized nutritional intake via gastrostomy and semi-solid foods, prevention of infections and bed ulcers, regular check-ups with specialists in rehabilitation, neurology, and thoracic surgery, as well as pharmacological treatment involving antiplatelet medication, gastroprotection, analgesics, neurotrophic and neuroleptic agents, antiepileptics, and antispasmodics.

2. Discussions

This case report highlights the complex management of a 22-year-old male patient who sustained severe polytrauma as a result of a motor vehicle accident. TBI is cited in the literature as a “silent epidemic”, given the high mortality rates even among young age [2,14], and is the main culprit for VS/UWS. With prompt and effective neurorehabilitation, patients may exhibit progress, occasionally advancing to a minimally conscious state and rarely achieving normal consciousness [10,13].

The case presented demonstrates the importance of tailored treatment approaches encompassing multiple pharmaceutical interventions, incorporating interventions like passive robotic kinesiotherapy to maintain an adequate ROM of the joints, prevention of sarcopenia, and botulinum toxin administration to manage focal spasticity [11,14].

The neurorehabilitation program was tailored to meet the patient's multifaceted needs requiring confidence, purposeful determination, and extensive experience in multidisciplinary interventions [8,10,13,15].

3. Conclusions

This case underscores the importance of multi-/interdisciplinary approaches in managing patients with severe polytrauma and extensive neurological impairments. The coordinated efforts of our specialists in neurology, neurorehabilitation, and thoracic surgery were significant in the patient's gradual recovery.

The comprehensive rehabilitation program, encompassing respiratory and skin care, nutritional management, bladder re-education, and psychological support, played a crucial role in the patient's long-term outcomes. Botulinum neurotoxin type A reduced spasticity, contributing to better nursing programs.

Despite the complexity of the case and the severe nature of the injuries, the rehabilitation program led to meaningful, albeit limited, improvements in the patient's condition.

The patient's *ad vitam* prognosis remains guarded, with long-term functional outcomes heavily dependent on a personal carer's rigorous rehabilitative nursing, sustained psychological support (both for the patient and his legal carers), and vigilant prevention of complications such as infections and pressure ulcers. Although the *ad functionem* outcomes remained minimal and *ad vocational* prognosis was null, the ongoing rehabilitation efforts aim to enhance his quality of life and reintegration into his family environment.

The Phoenix symbolically takes gradual steps toward fulfilling its destiny - to rise from its ashes.

This case emphasizes the critical need for heightened awareness about road safety and preventive measures while driving, underscoring the profound impact of road accidents on individuals and the healthcare system.

Abbreviations:

TBI: Traumatic Brain Injury	PVS: Persistent Vegetative State	UWS: Unresponsive Wakefulness Syndrome
CT: Computed Tomography	ICU: Intensive Care Unit	PEG: Percutaneous Gastrostomy
MDR: Multidrug Resistant	NMAK = neuro-myo-arthro-kinetic	ROM: Range of Motion

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Informed Consent Statement: Informed consent was obtained from the patient's family, considering his cognitive status of a persistent vegetative state.

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Conflicts of Interest: The authors declare no conflict of interest.

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