





NEUROSURGERY AND NEUROREHABILITATION IN THE AI ERA: A HOLISTIC APPROACH

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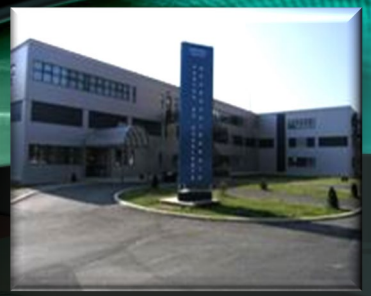
Matei Serban Razvan Covache Andrei Popa

















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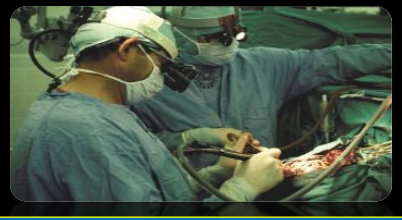
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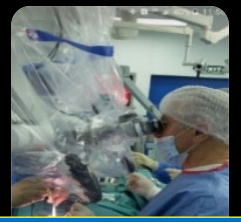
Honorary Member of the Romanian Academy,
Medical Science Section
Honorary President of the Romanian Society of Neurosurgery
Ex-VicePresident of the WFNS
Ex-Chairman of the WFNS Nomminating Committee
Representative for Europe in the WFNS NC.
Visiting Professor Harvard University School of Medicine
Visiting Professor INI Hannover
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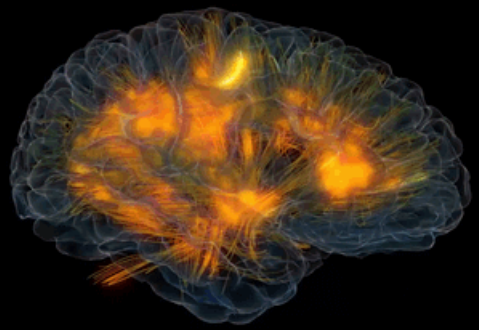


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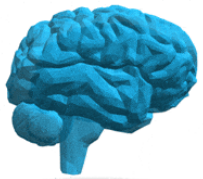




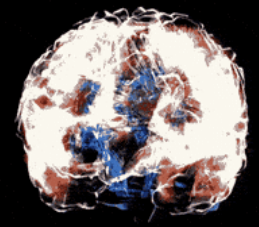
SUMMARY

- 1. INTRODUCTION
- 2. HISTORY AND IMPACT IN POSTOPERATIVE NEURO-RECOVERY
- 3. NEUROSURGICAL PATHOLOGY
- 4. IMPORTANT INVESTIGATION IN NEUROSURGICAL PATIENTS
- 5. PRINCIPLES OF NEURO-RECOVERY
- 6. TYPES OF INTERVENTIONS
- 7. ACTUALITIES OF INTERVENTIONS IN NEURO-RECOVERY
- 8. POSTOPERATIVE RECOVERY
- 9. CONCLUSIONS



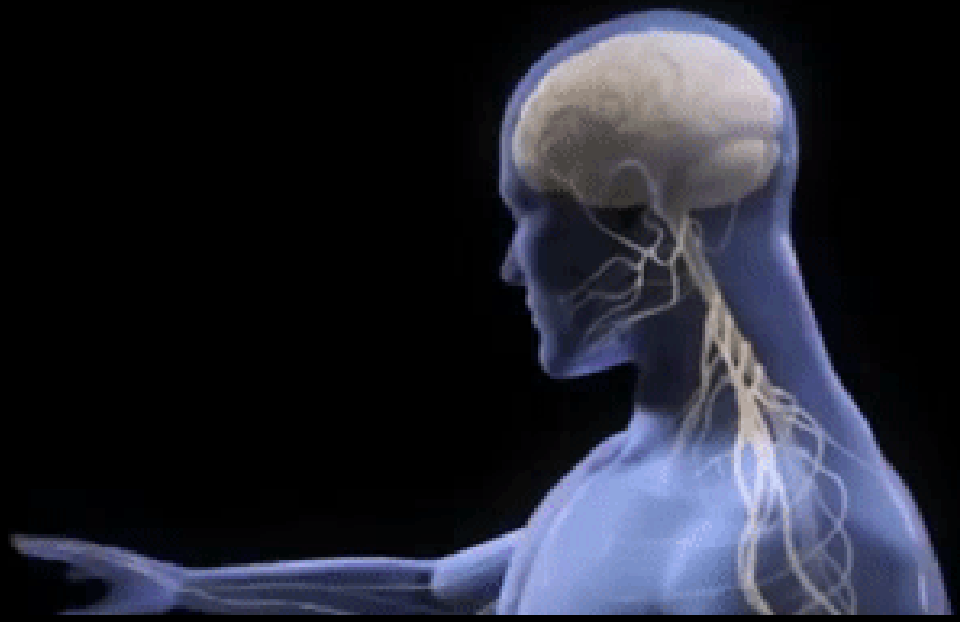


INTRODUCTION



- **Neuro-recovery** is a complex branch of medical rehabilitation that aims to restore the functions of the nervous system.

BE AWARE – A NEW MEDICAL BRENCH



This involves multidisciplinary interventions and begins, ideally, immediately after the **postoperative patient's stabilization.**

IMPORTANT QUOTE



January 12th, 1949
Best seller author

„I move, therefore I am”
(Haruki Murakami)
(1949-1971)











MOTILITY vs. MORBIDITY



PLEASE, YOUR CHOICE

Motility VS. Morbidity

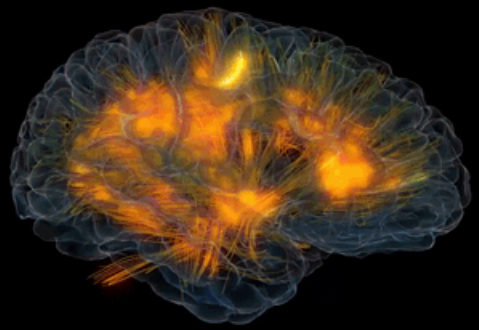




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HISTORY AND IMPACT IN POSTOPERATIVE NEURO-RECOVERY

STAGE I – Theoretical foundations (1890–1940)

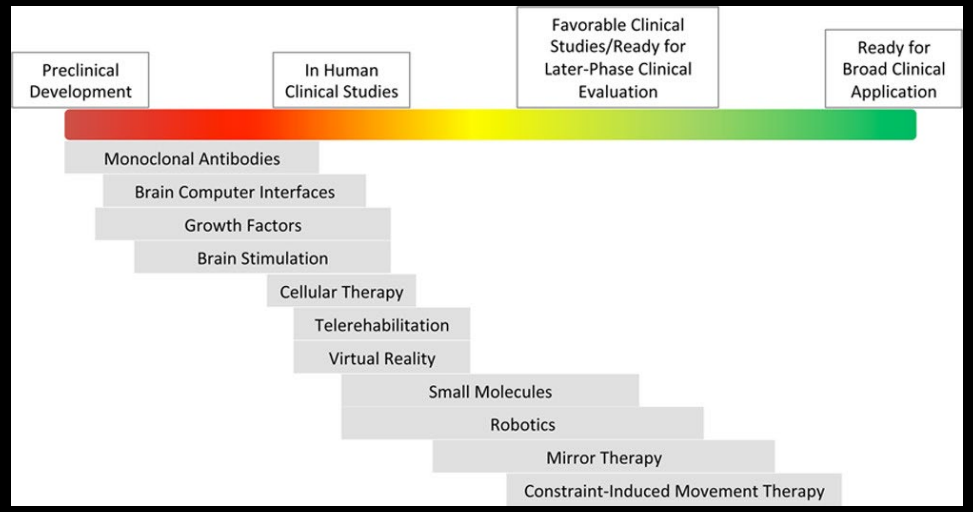
STAGE II – First clinical interventions (1940–1960)

STAGE III – Major conceptual changes (1960–1980)

STAGE IV – Scientific consolidation (1980–2000)

STAGE V – Technology and Customization (2000–Present)

STAGE VI – Artificial Intelligence (2025 & Future)



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STAGE I – Theoretical foundations (1890–1940)

- **1890 – William James** introduces the concept of "neuroplasticity."
- **1920–1930: Lev Semionovici Vygotsky and Alexander Romanovici Luria** develop the foundations of Russian neuropsychology.
- The first attempts to understand the reorganization of the **TRAUMATIC BRAIN INJURIES.**



William James (1842 – 1910)
- **The founder of "neuroplasticity"**
- *Harvard University-The Principles of Psychology* (1890)

STAGE II – First clinical interventions (1940–1960)

The rehabilitation of war veterans has boosted the field.

Techniques of electrical stimulation of the motor cortex.

1928: Frank Krusen founds the first Rehabilitation Department at Temple Hospital (Philadelphia, U.S.A)

Where rehabilitation started



Frank Krusen (1898–1973)
- Founder of Rehabilitation and Recovery Medicine-

STAGE III – Major conceptual changes (1960–1980)

Neurorehabilitation is emerging as a distinct medical discipline.

Methods appear: Bobath therapy, PNF (proprioceptive neuromuscular facilitation).

Modern **occupational therapy** is developing.



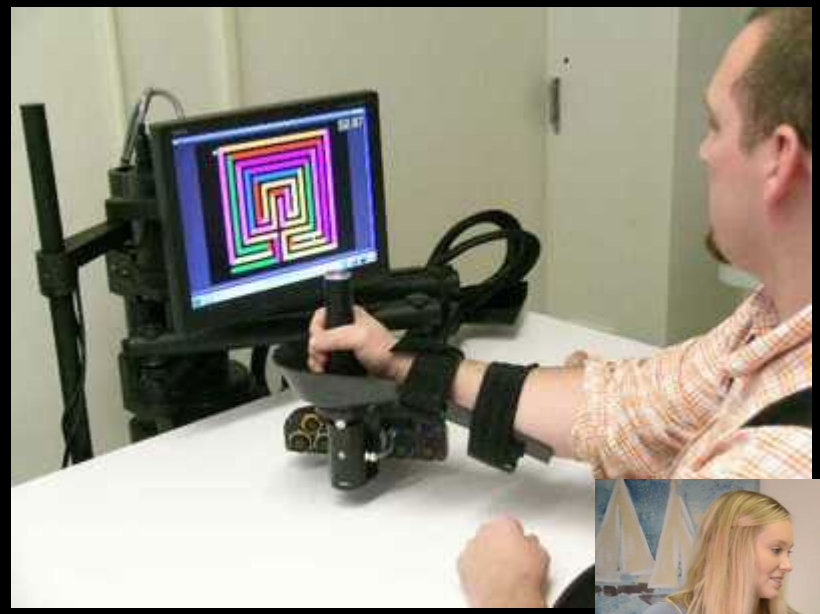


STAGE IV – Scientific consolidation (1980–2000)

Introduction of robotics (MIT-Manus) Massachusetts Institute of Technology.

Confirmation of neuroplasticity in the adult brain.

Rehabilitation based on clinical evidence.





STAGE V – Technology and Customization (2000–Present)

Virtual reality, AI and robotics in treatments.

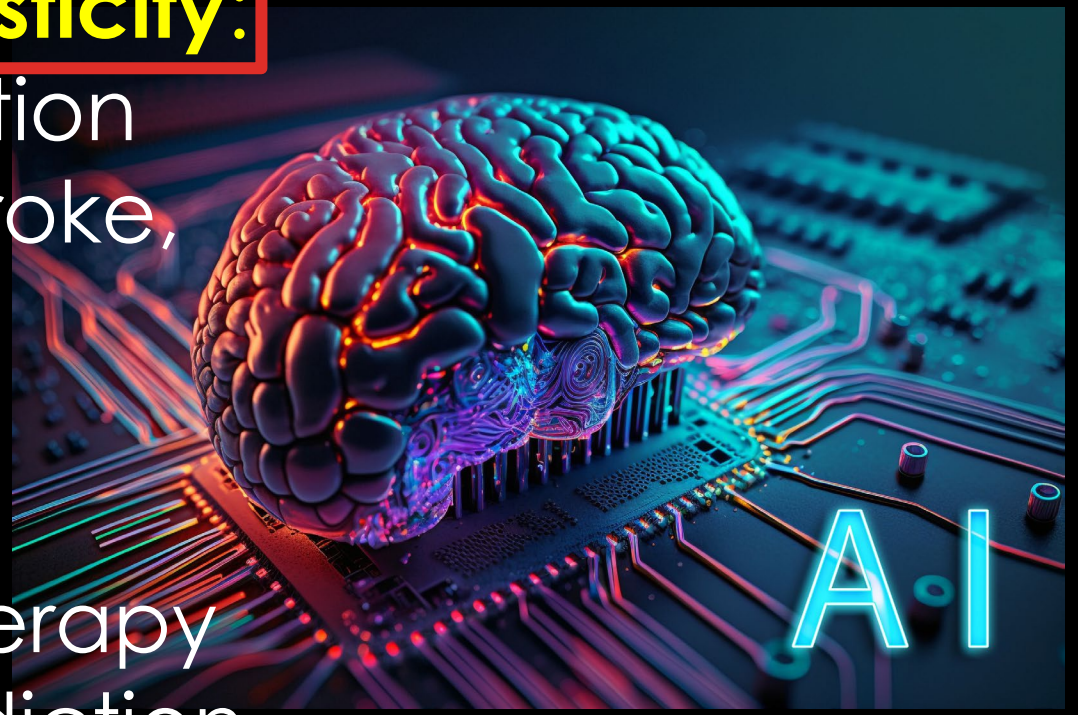
Telerehabilitation and digitization of interventions.

Personalization of therapies according to the cognitive profile.



STAGE VI – Artificial Intelligence (2025 & Future)

- **Neurorehabilitation and Neuroplasticity:**
- Therapy aimed at improving function after **nervous system injury** (e.g., stroke, TBI, spinal cord injury).

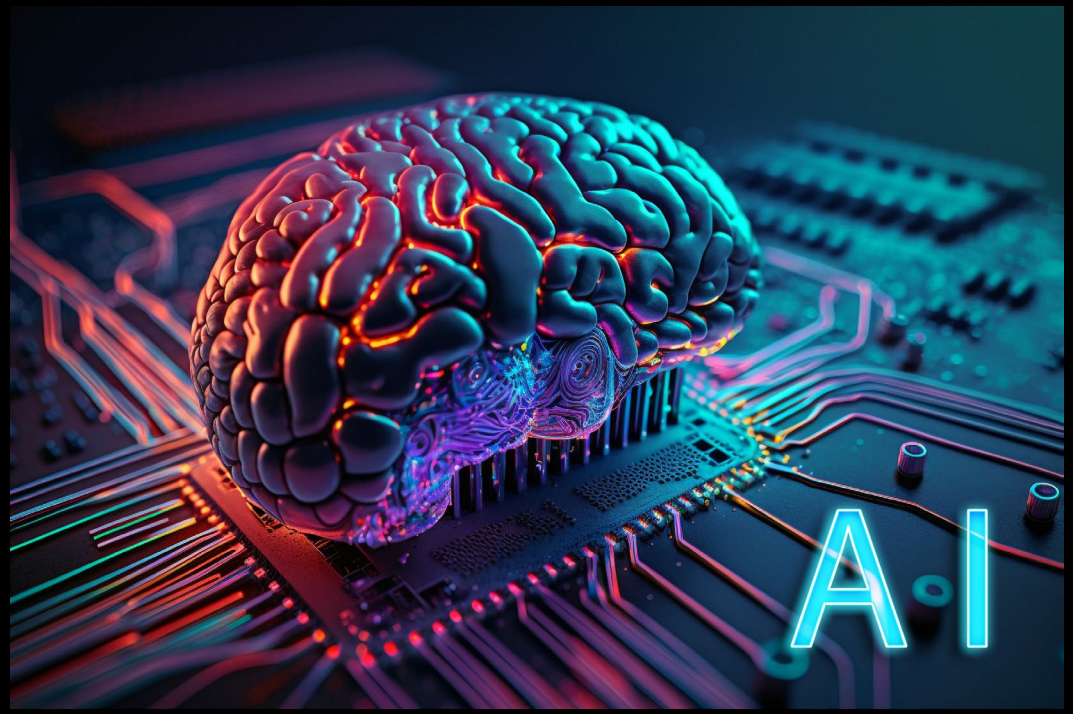


- **AI's Role** Enhancing diagnosis, therapy personalization, and outcome prediction

STAGE VI – Artificial Intelligence (2025 & Future)

Benefits

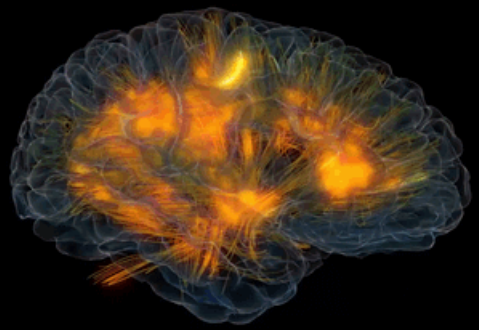
- **Personalized**, data-driven therapy.
- Continuous **monitoring** outside clinical settings.
- **Earlier interventions** and better long-term outcomes.



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Cerebral and Spinal Pathologies Requiring Rehabilitation

Cerebral Pathologies



1. Traumatic Brain Injury (TBI)

2. Stroke (Ischemic & Hemorrhagic)

3. Cerebral Palsy

4. Brain Tumors & Post-Surgical Recovery (vascular malformation; brain malformation etc.)

5. Neurodegenerative Diseases

Cerebral and Spinal Pathologies Requiring Rehabilitation

Spinal Pathologies



1.Spinal Cord Injury (SCI)

2.Intrarahidian tumors and vascular pathology

3.Spinal Stenosis / Herniated Discs/ Spondylolisthesis

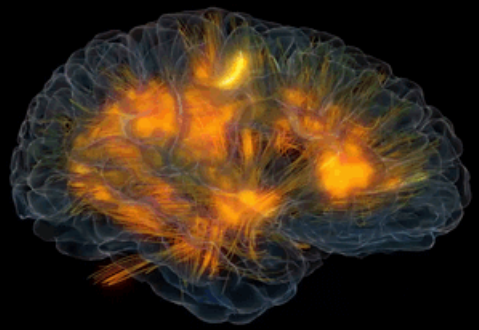


4.Multiple Sclerosis (MS)

5.Post-Surgical Spinal Rehabilitation







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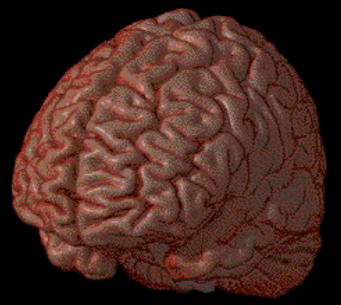
IMPORTANT INVESTIGATION IN NEUROSURGICAL PATIENTS

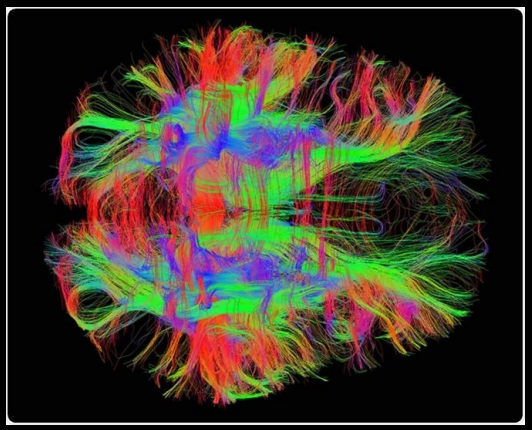
CEREBRAL PATHOLOGIES

1.Neuroimaging
CT multislice
MRI,
fMRI,
DTI & Brainmapping evaluation,
angiography









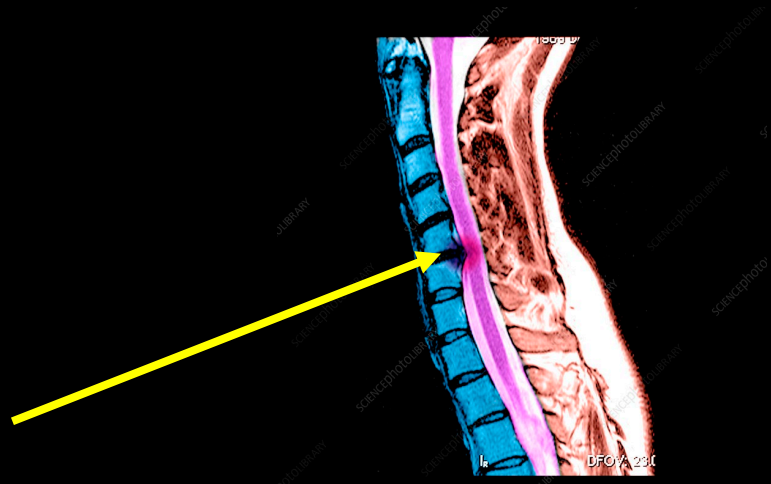
2.EEG, repeated and multifunctional

3.Complete oftalmological and ORL investigation

IMPORTANT INVESTIGATION IN NEUROSURGICAL PATIENTS

SPINAL PATHOLOGY

1. Neuroimaging
X-Ray standard
CT multislice (native & contrast)
CT 3D (mandatoy for spine)
MRI

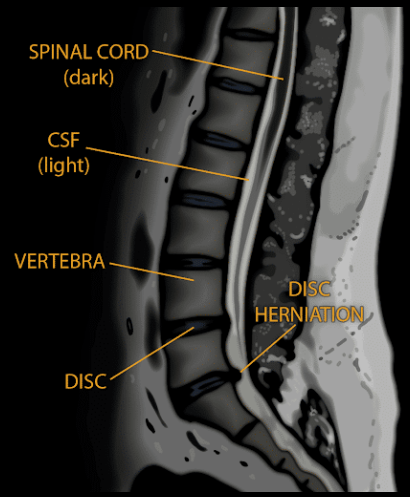


2.EMG and repeated

3.CSF evaluation (lombar punction) +/-

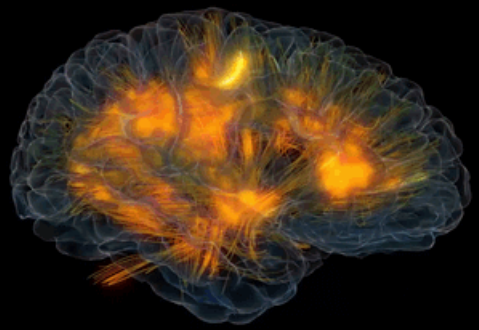
4.Abdominal ecography +/-

5.PET scan & scintigraphy +/-









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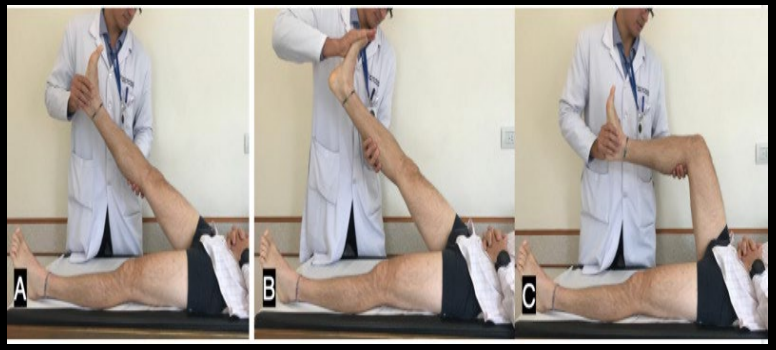


PRINCIPLES OF NEURO-RECOVERY

KEY COMPONENTS OF THE INITAL EVALUATION

1.Complete Clinical Examination

Motor, sensory, cognitive, and reflex assessments
Functional scales (e.g., NIHSS, FIM)



2.Neurophysiological Monitoring

EEG: Detects abnormal brain activity (e.g., seizures, brain function)
EKG: Monitors cardiac status, crucial in stroke and TBI patients

3.Neuroimaging

- **MRI**: Identifies structural damage, ischemia, or hemorrhage
- **fMRI**: Maps brain activity and functional connectivity

PRINCIPLES OF NEURO-RECOVERY

- INDIVIDUALIZATION OF TREATMENT
- REPETITIVENESS AND INTENSITY
- TIME OF THE INTERVENTION (THERAPEUTIC WINDOW)
- ACTIVE PATIENT PARTICIPATION
- MULTIDISCIPLINARY TEAM
- CONTINUOUS MONITORING AND ADJUSTMENT



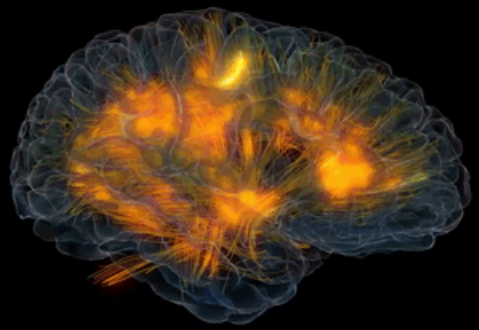
KINETOTHERAPY IS ESSENTIAL



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TIME OF THE INTERVENTION (THERAPEUTIC WINDOW)

- THE **FIRST DAYS/WEEKS AFTER THE INJURY** ARE CRITICAL FOR GOOD RESULTS.
- **EARLY INTERVENTION MAXIMIZES** NEUROPLASTICITY.
- IN **CHRONIC CASES, PROGRESS IS POSSIBLE,** BUT MORE SLOWLY.



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INDIVIDUALIZATION OF TREATMENT

- **Interventions must be adapted** according to:
  - type and severity of injury, comorbidities
  - Age
  - Functional level
  - personal goals.





Customized **rehabilitation plans increase** adherence and efficiency.

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PHYSICAL THERAPY

- **Objectives:**
  - improved strength
  - Balance
  - coordination and mobility.



- **Techniques**
  - Strengthening exercises
  - gait training
  - postural re-education.
- **Applications:** stroke recovery, spinal cord injury, multiple sclerosis.

REPETITIVENESS AND INTENSITY

Repetitive exercises create new neural circuits.

Exercises should be frequent and sustained to stimulate neural reorganization.

Increased intensity is associated with faster and longer-lasting recoveries.



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SPEECH THERAPY

- Addressed to speech, language and swallowing disorders.

- **Techniques:**
  - articulation exercises
  - therapy for aphasia
  - Compensation strategies.

- **Apps:**
  - AVC
  - head trauma
  - post tumor resection
  - neurodegenerative diseases.



OCCUPATIONAL THERAPY

- **Goal:** restoration of the ability to perform daily activities (ADL).

- **Intervention:**
  - Dressing training
  - Cooking
  - Personal hygiene.

- **Adaptations:**
  - Use of assistive devices
  - Environmental changes.



ACTIVE PATIENT PARTICIPATION

- The patient is an active partner in the rehabilitation process.
- Patient engagement increases motivation and adherence.
- Patient education is essential for progress.







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CONTINUOUS MONITORING AND ADJUSTMENT

- **Progress** must be constantly monitored.
- The **objectives** are adjusted according to the patient's evolution.
- **Tools:** functional scales, cognitive tests, periodic assessments.





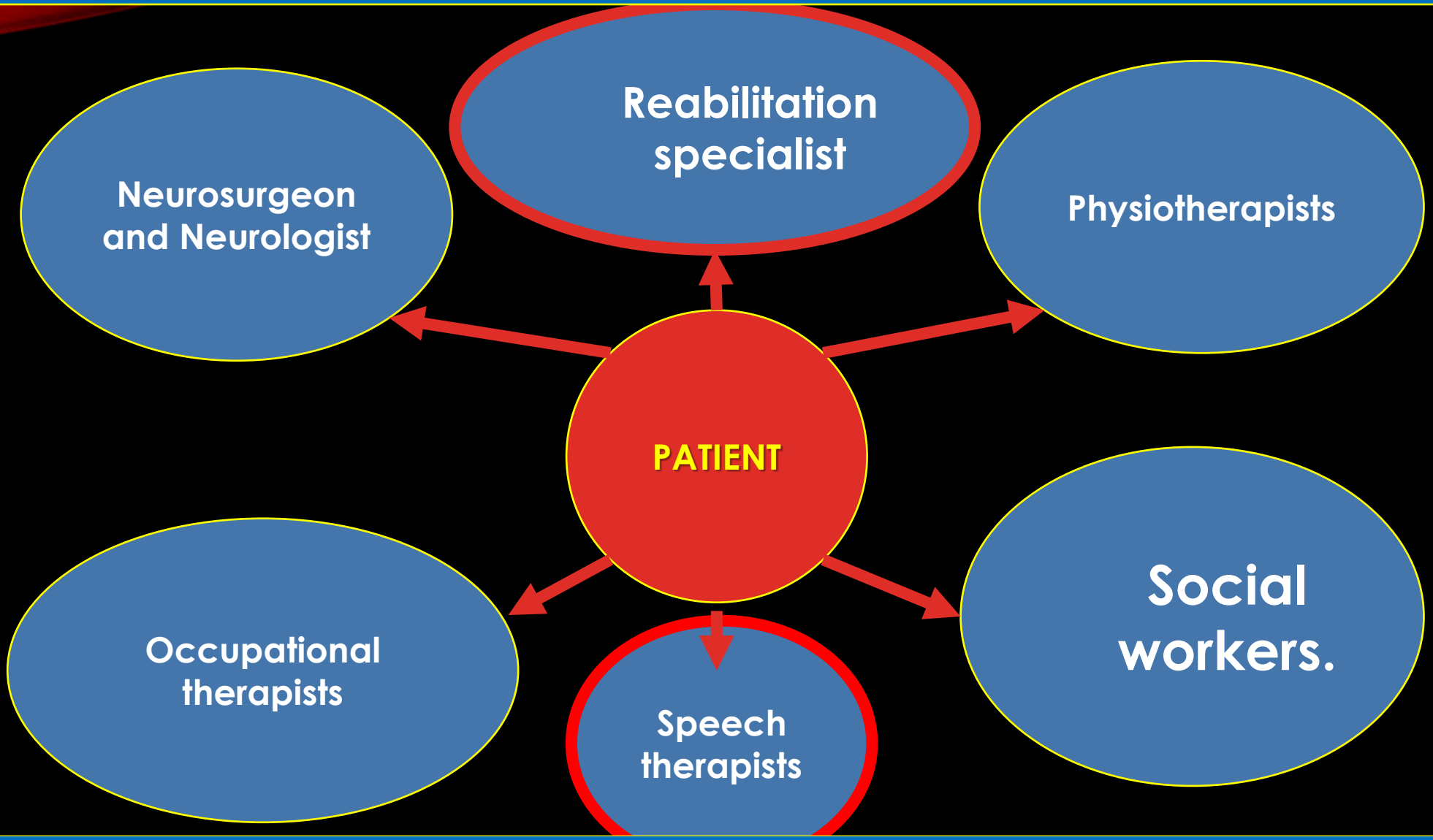
MULTIDISCIPLINARY TEAM

- **COLLABORATION BETWEEN :**
  - Neurosurgeon and Neurologist
  - Reabilitation specialist
  - Physiotherapists
  - Occupational therapists
  - Speech therapists
  - Psychologists
  - Social workers.



- **All disciplines** contributes to a coherent and effective plan.
- Total communication between specialists is essential.

MULTIDISCIPLINARY TEAM



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REHABILITATION BOARD

A rehabilitation board is a meeting made up of specialized doctors and other health care providers who regularly gather to discuss neuro cases.

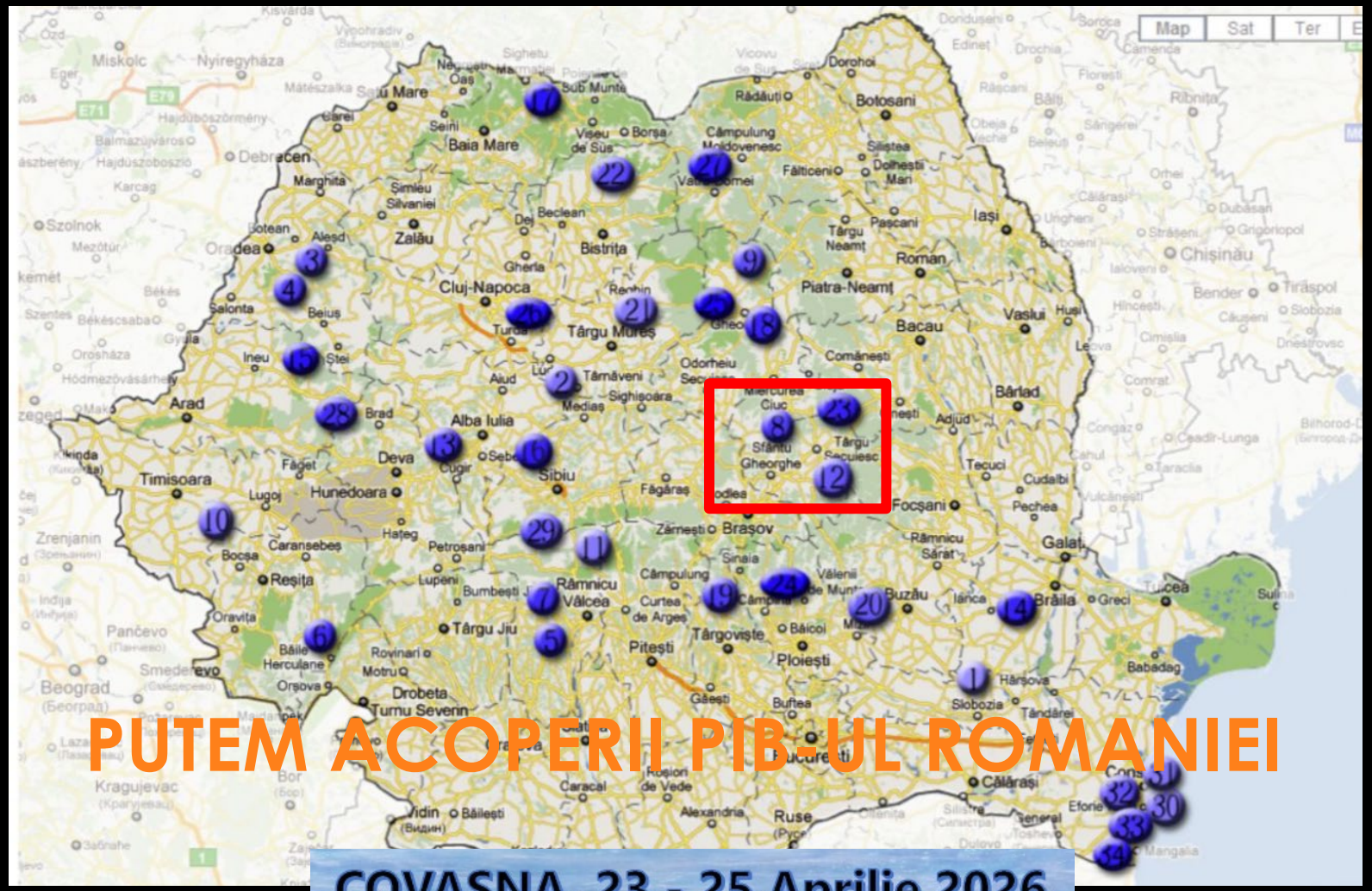
MEDIEVAL ROUND TABLE



1155 d.Hr.

The goal is to decide on the best possible treatment plan for a patient as a group.

IMPORTANT NEURORECOVERY CLINICS IN BUCHAREST



IMPORTANT NEURORECOVERY CLINICS IN BUCHAREST



Centrul Național Clinic de Recuperare Neuropsihomotorie Copii „Dr. Nicolae Robănescu”

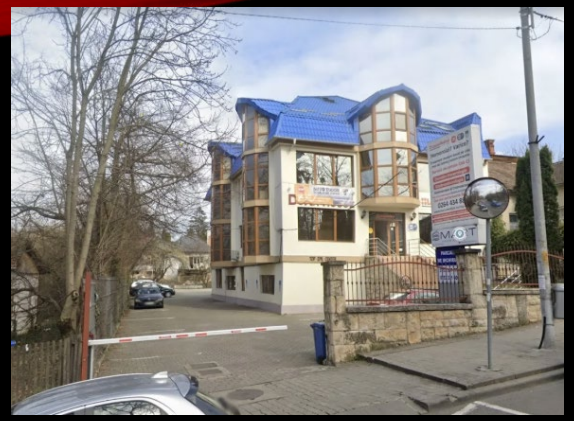


Clinica de Neurorecuperare – Spitalul de Urgenta Bagdasar-Arseni

Institutul Național de Recuperare Medicină Fizică si Balneoclimatologie



IMPORTANT CLINICS IN COUNTRY NEURORECOVERY



CLINICA BRAINTECH
CLUJ NAPOCA



SPITALUL CLINIC DE RECUPERARE
MEDICALA BAILE FELIX



SPITALUL MULTIDISCIPLINAR
ARCADIA



SANATORIUL BALNEAR ȘI DE
RECUPERARE TECHIRGHIOL

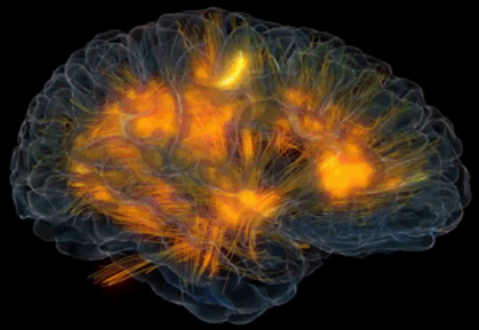


SPITALUL NOVA VITA
TÂRGU-MUREŞ

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NEUROPLASTICITY STIMULATION



It is defined as the ability of the nervous system to change its activity in response to intrinsic or extrinsic stimuli

The Brain can reorganize

- Structure
- Functions
- Connections

after injuries, such as a stroke or traumatic brain injury (TBI).



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NEUROPLASTICITY

TOTAL SUPPORT

FOR REHABILITATION

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NEUROPLASTICITY IN TBI

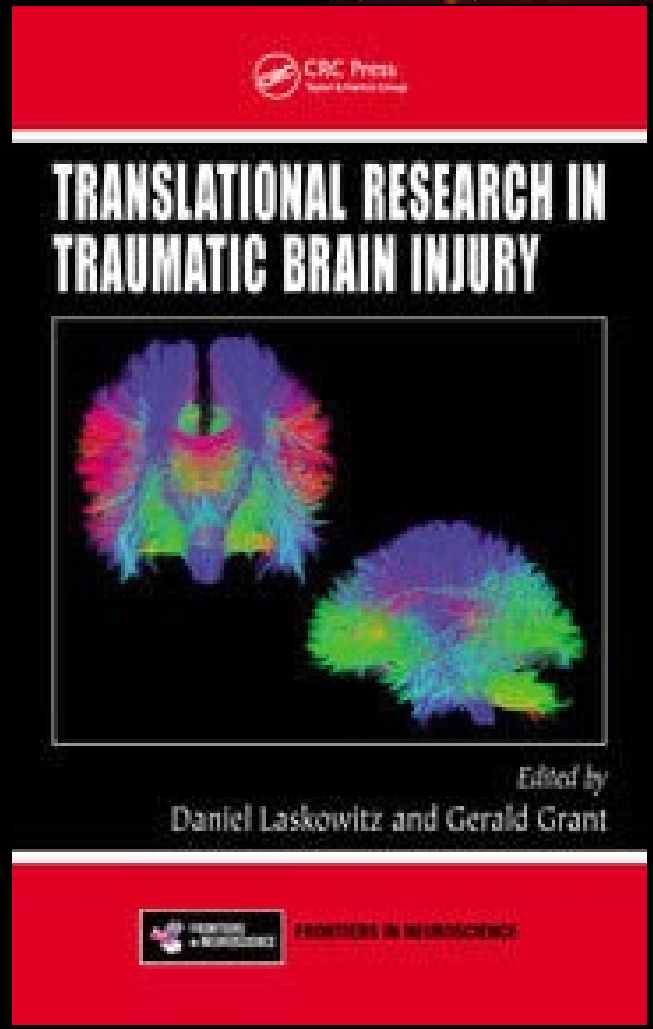


Mechanism steps:

- **First 48h:** initial lesions from dead cells
Usage of **secondary neural networks**

- **Next weeks:** cortical pathways **from inhibitory to excitatory** mechanisms

- **Next months:** **axonal growth** and **perilesional reorganization**



Su et al. 2016

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COGNITIVE REHABILITATION

- **Improvement of cognitive functions:** memory, attention, executive functions.

- **Methods:**
  - cognitive training
  - Specialized software
  - compensatory strategies.



- **Applications:** TBI, postop neurosurgery, dementias, multiple sclerosis.

FUNCTIONAL ELECTRICAL STIMULATION (FES)

- Uses **electrical impulses** to stimulate weakened muscles.

- **Benefits:**
  - improved gait
  - prevention of muscle atrophy.

- **Apps:**
  - Paraplegia
  - Post-stroke hemiparesis
  - Sclerosis.





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PSYCHOLOGICAL AND PSYCHOSOCIAL INTERVENTIONS

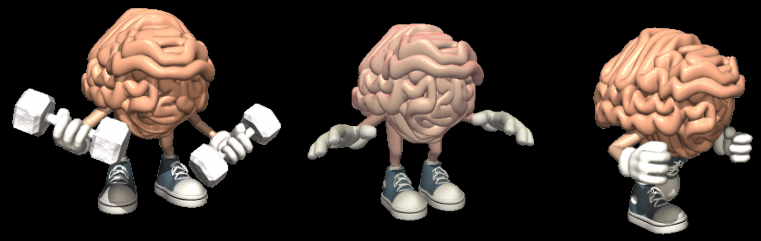
- **Psychological counseling** for adapting to the new living condition.
- **Group therapy** and **social support** for reintegration.
- **Management of stress,** anxiety and depression associated with disability.



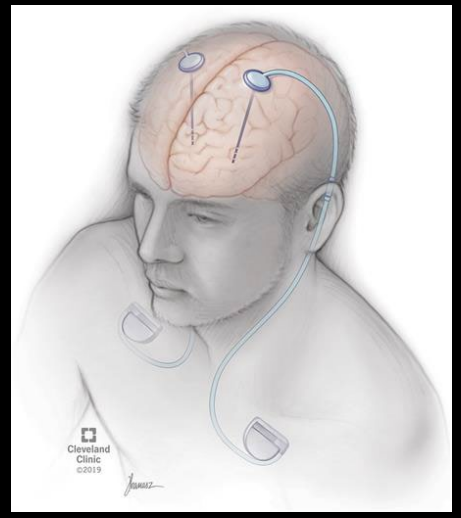
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ACTUALITIES IN NEURORECOVERY

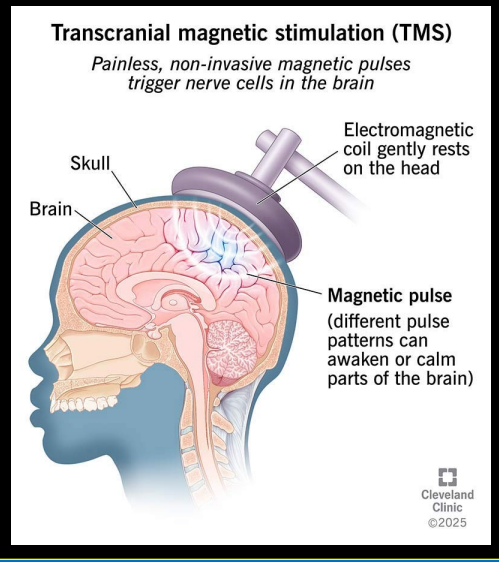
- **Feedback:** Brain Stimulation



DEEP BRAIN STIMULATION



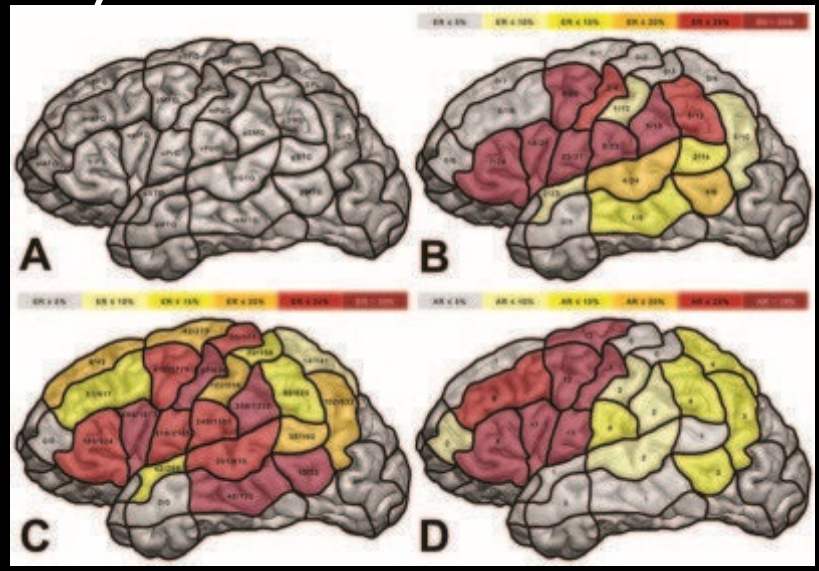
TRANSCRANIAL STIMULATION



Ciurea et al., 2026

FUTURE OF NEURORECOVERY

Brain mapping with electrical stimulation involves applying electrical impulses to the surface of the brain (cortex) to identify areas responsible for essential functions such as speech or movement.



This technique, also known as "**Cortical Stimulation Mapping**," is used to plan surgical interventions while minimizing postoperative functional deficits.

Ciurea et al., 2026

FUTURE OF NEURORECOVERY

Benefits

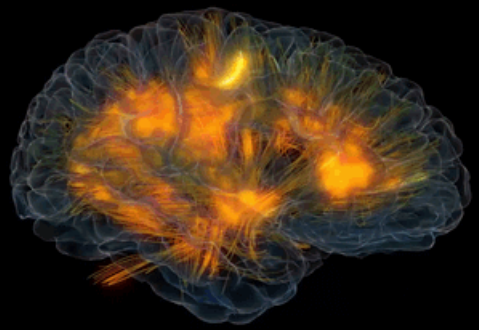
…….UNLIMITED

- **Precision in Surgical Planning**
  ➤ Reduces the risk of postoperative neurological deficits.

- **Improved Understanding of Brain Function**
  ➤ Helps clarify the role of different cortical areas in functions such as language, motor control, and perception.







SUMMARY

- 1. INTRODUCTION
- 2. HISTORY AND IMPACT IN POSTOPERATIVE NEURO-RECOVERY
- 3. NEUROSURGICAL PATHOLOGY
- 4. IMPORTANT INVESTIGATION IN NEUROSURGICAL PATIENTS
- 5. PRINCIPLES OF NEURO-RECOVERY
- 6. TYPES OF INTERVENTIONS
- 7. ACTUALITIES OF INTERVENTIONS IN NEURO-RECOVERY
- 8. POSTOPERATIVE RECOVERY
- 9. CONCLUSIONS



POSTOPERATIVE NEURO-RECOVERY IN NEUROSURGERY

POSTOPERATIVE CONTEXT IN NEUROSURGERY

- **Neurosurgical interventions** can lead to:
  - Motor deficits
  - Speech or cognitive disorders
  - Orientation disorders
  - Balance or coordination problems
- **Neurorecovery** often begins immediately after surgery
- It requires **close collaboration** between neurosurgeon, physiotherapist, speech therapist and psychologist



Ciurea et al., 2026

OBJECTIVES OF POSTOPERATIVE NEURORECOVERY

- **Restoration** of impaired neurological function
  - Prevention of secondary complications:
  - muscle atrophy,
  - Venous thrombosis,
  - Trophic disorders
- **Increasing** independence in daily activities
- **Improving** quality of life and reintegration into family/society



TYPES OF POSTOPERATIVE INTERVENTIONS

- **Early Physical Therapy:**
  - Mobilization
  - Muscle Toning
  - Assisted walking
- **Speech therapy:** for patients with aphasia, dysarthria or swallowing difficulties
- **Occupational therapy:** resuming daily activities
- **Cognitive and psychological rehabilitation:** memory stimulation, emotional support







Ciurea et al., 2026

LOMBAR DISC HERNIATION RESULTS I – STANDARD OP, MICRODISCECTOMY



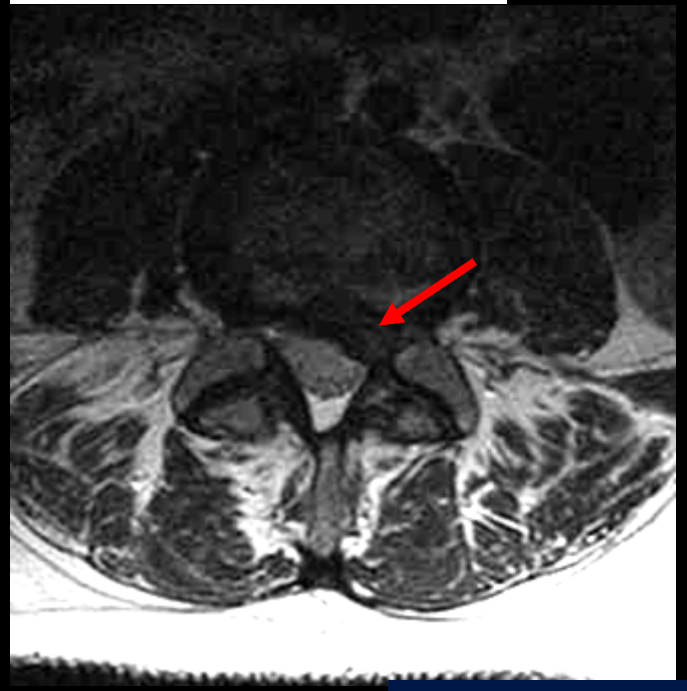




SANADOR OP THEATER

LDH RESULTS I





PREOPERATIVE

B.I. , Male, 52 y.,







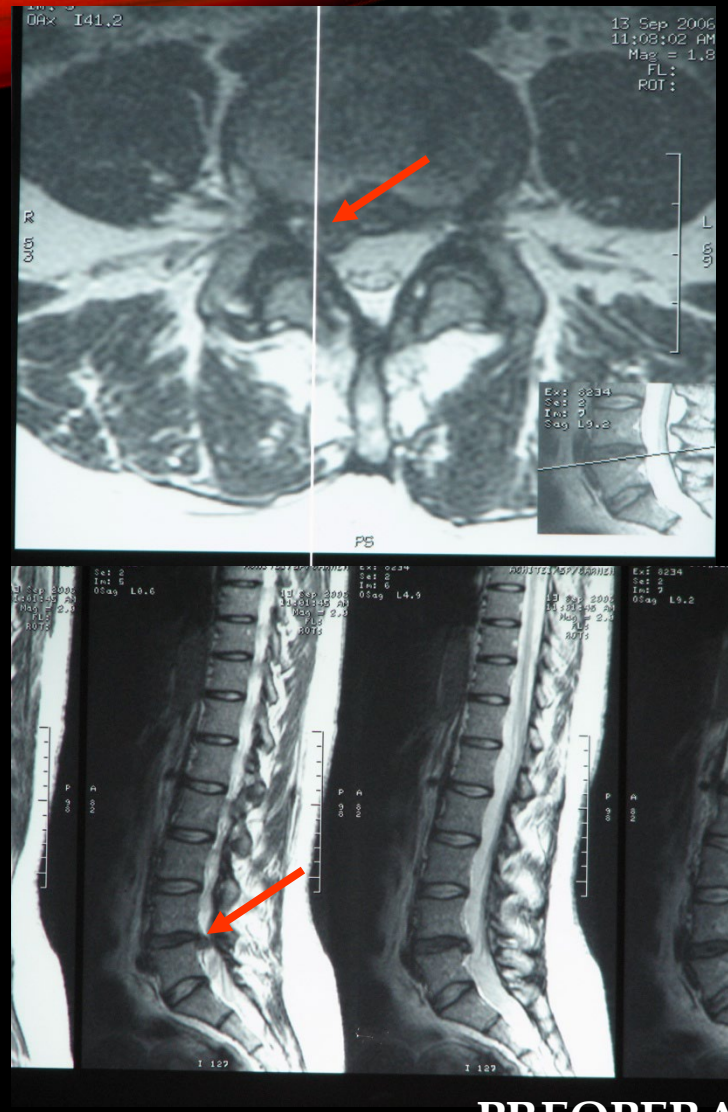
POSTOPERATIVE, 2 mo.

MICRODISCECTOMY



Ciurea et al., 2026

LDH RESULTS II



A.C., female, 34 y.,
HDL L4 right



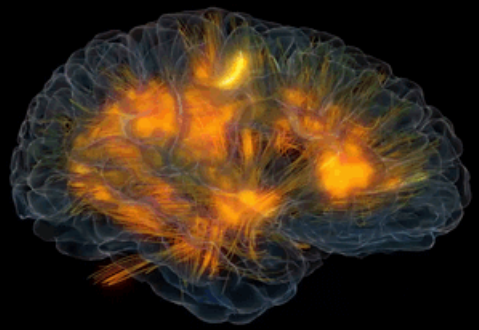


PREOPERATIVE

POSTOPERATIVE, 1 w.





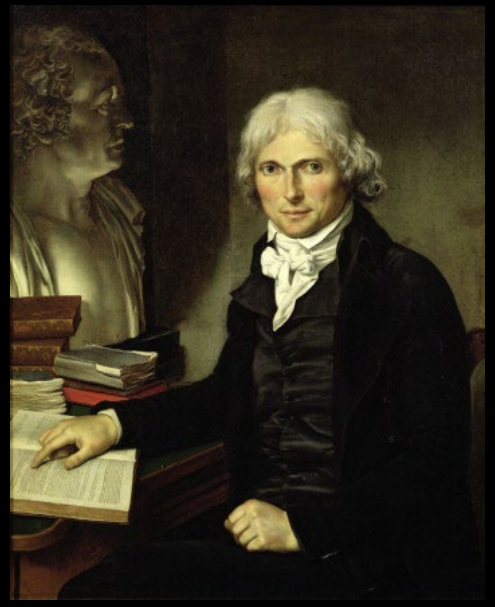


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"La fonction crée l'organe"



Marie François Xavier Bichat (1771–1802)





Jean-Baptiste Lamarck (1744–1829)

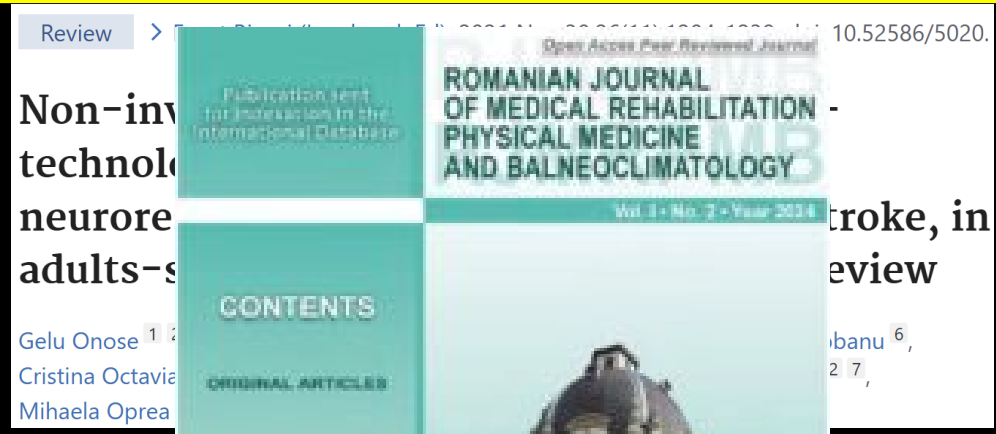
Ciurea et al., 2026

SCIENTIFIC EVIDENCE AND STATISTICS

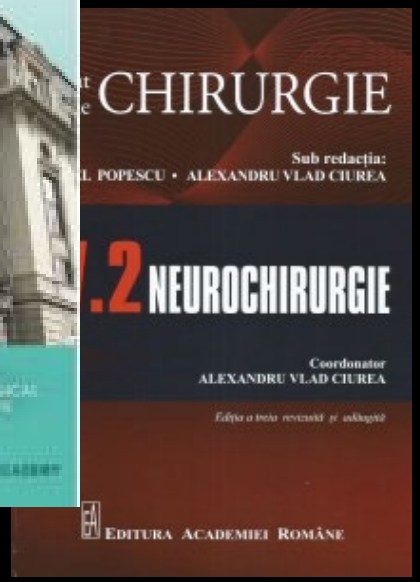
IMPORTANT PUBLICATIONS:

Meta-analyses: early therapies increase quality of life

Data supported by clinical trials







Ciurea et al., 2026

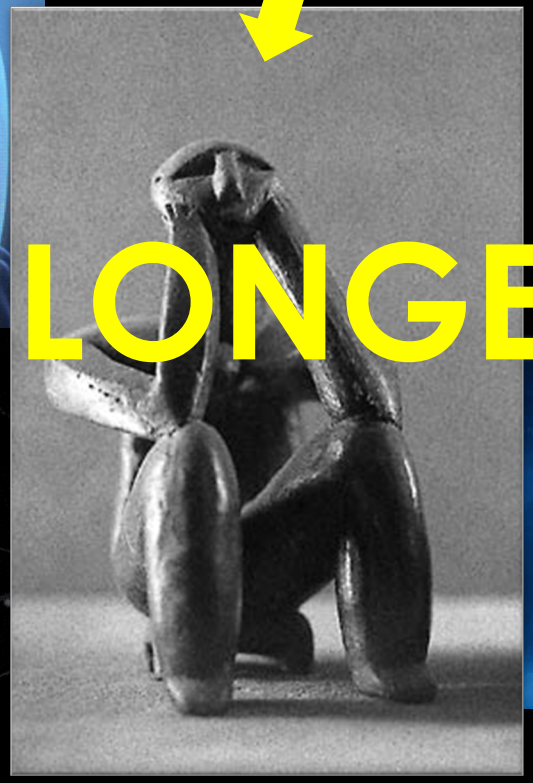
NEUROREBILITATION: LONGEVITY

- Do we know all the anatomical structures of the brain?



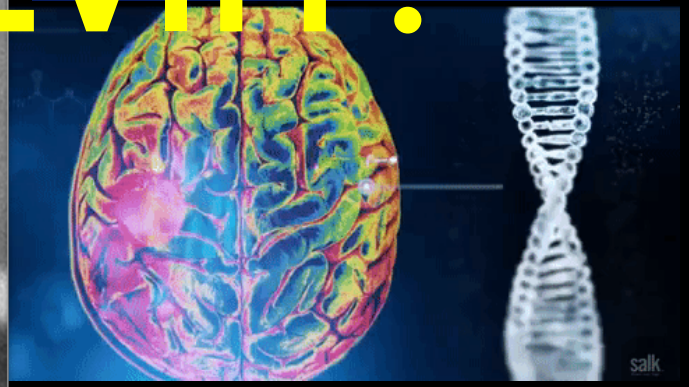


- How much can we use our brain ?



- Is the improvement of brain function possible ?





- What are the neural activities?

AND LONGEVITY?

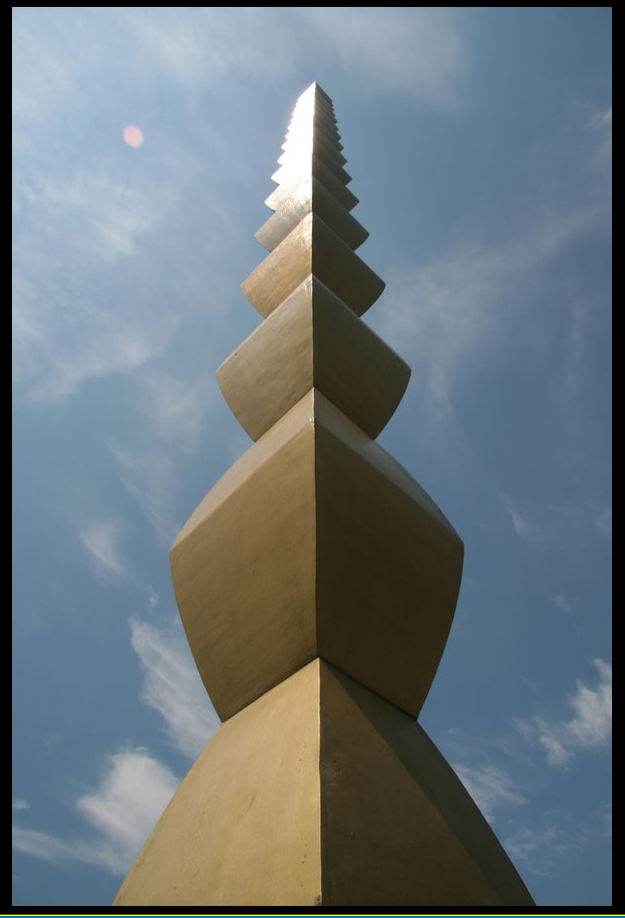
HEALTH BRAIN MENTENANCE?

Ciurea et al., 2026

CONCLUSIONS

Neurorehabilitation is the most important pillar in the family and social integration of postoperative neurosurgical patients

The neurosurgical patient without the help of neurorehabilitation cannot leave the hospital!!



CONCLUSIONS

IMPORTANT: EARLY NEUROREABILITATION



IMPORTANT TASK: PERSONALIZED NEUROSURGICAL BOARD FOR EACH CASE

WITHOUT NEUROREHABILLITATION – NO FAMILIAL & PROFESSIONAL INTEGRATION

Ciurea et al., 2026

THE VISIONARY



In 1975, the NEUROSURGICAL CLINIC had a total of 550 beds.

Contained seven well-defined clinical departments.

Created NeuroReabilitation Dpt, one full level, 62 beds



TAKE HOME MESSAGE

NEUROREHABILITATION STARTED EARLIER (AS SOON AS POSSIBLE) IN ALL NEUROSURGICAL PROCEDURES



Spitalul Bagdasar- Arseni



Spitalul SANADOR



SUUB



Spitalul ELIAS

TAKE HOME MESSAGE



"Without oil, the world stops!"







"Without rehabilitation after neurosurgery, functional recovery is impossible!"

Ciurea et al., 2026

ROMANIA IN IMAGES





CONCLUSIONS



BRAIN MENTENANCE = COSMIC MENTENANCE



Men sana in corpore sano



OUR AIM: HEALTHY BRAIN AND LONGEVITY MENTENANCE!

Ciurea et al., 2026