

NATIONAL ACADEMIES Sciences Engineering Medicine

Exploring the Treatment and Management of Chronic Pain and Implications for Disability Determinations: A Workshop

Thursday, April 17, 2025, 9:00am – 5:00pm ET
Friday, April 18, 2025, 9:00am – 1:30pm ET
Kirk Center | 800 6th Street NW, Washington, D.C., 20001

Session VII: Emerging Research on New or Improved Methods for the Measurement and Management of Chronic Pain

Moderator: Sean Mackey, Stanford University, Planning Committee Member

Objective: Receive an overview of recent or emerging research on new or improved methods for the measurement and management on chronic pain.

Current State and Future Directions in Neuromodulation for Pain

Konstantin Slavin, MD, FAANS
University of Illinois at Chicago




Disclosure

ins International Neuromodulation Society

WFS World Society for Stereotactic and Functional Neurosurgery

Cancer Pain Research Consortium

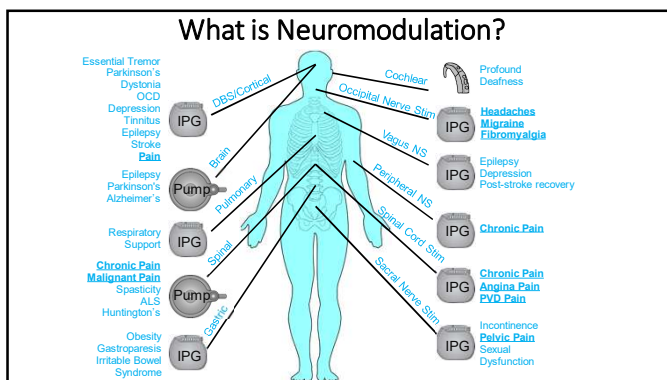
Progress in Neurological Surgery
Editor K.V. Slavin
Karger

ASSFN American Society for Stereotactic and Functional Neurosurgery

brain sciences MDPI

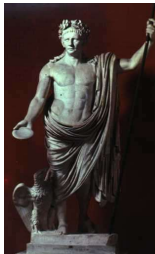
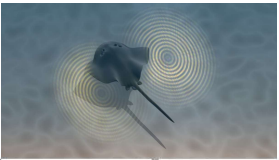
SNI SURGICAL NEUROLOGY INTERNATIONAL

American Interventional Headache Society

History of Neuromodulation

Claudius (Tiberius Claudius Nero Germanicus): 10 B.C.E. - 54 C.E.
Roman Emperor: 41 C.E. - 54 C.E.
Invaded and annexed Britain - 51 C.E.
In his entourage - the physician **Scribonius Largus**

SCRIBONIUS LARGVS

SCRIBONI LARGI COMPOSITIONES MEDICAE
IOANNES RHODIVS
romulus
Nobilis Medicus
LEONARDUS SEVERINOLIVS
adnot.

With B. Claudius in exile comendat proleptus.
Petrus Calender Lamberdus AD. CD. DC. LXX.
MAIESTATI REGIAE

The book from antiquity (reprinted in January of 1645)



History of Neuromodulation



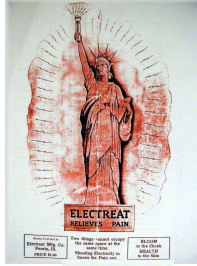
“For any type of gout a live black torpedo should, when the pain begins, be placed under the feet. The patient must stand on a moist shore washed by the sea and he should stay like this until his whole foot and leg up to the knee is numb. This takes away present pain and prevents pain from coming on if it has not already arisen. In this way Anteros, a freedman of Tiberius, was cured.”

Scribonius Largus, Rome, 1st century C.E.

COMPOSITIONES MEDICAE
Scribonius Largus...
GENERA MEDICAMENTORVM, ET DEMONSTRATIONES SERPENTVM ICTVS.



History of Neuromodulation

ELECTRICITY RELIEVES PAIN

Two things cannot occupy the same space at the same time.
Shooting Electricity in forces the Pain out.



Early 20th century



1967 – Spinal Cord Stimulation

ANESTHESIA and ANALGESIA . . . *Current Researches* Vol. 46, No. 4, JULY-AUGUST, 1967

Electrical Inhibition of Pain by Stimulation of the Dorsal Columns:

REPORT OF A CASE

A 70-year-old man was admitted to Lutheran Hospital in early March because of severe diffuse pain in the right lower part of the chest and the upper part of the abdomen. He had previously been demonstrated to have inoperable bronchiogenic carcinoma and was suspected of having metastasis to the pleura and liver. He ran a low-grade fever and had considerable nausea and vomiting but was thought to have a life expectancy of 1 or 2 months. We explained in detail to him and his family the experimental nature of dorsal column stimulation. A nurse anesthetist daughter was of great aid in gaining their acceptance of this treatment. On March 24, 1967, a thoracic laminectomy (T12-L1) was performed and a V-tellium electrode measuring 3 by 4 mm, was approximated to the dorsal column at D3 by suturing to dura. The spinal electrode was Vitallium covered with Dow Corning Medical Grade Adhesive and Silastic. Special subcutaneous jacks were placed inferior

Preliminary Clinical Report

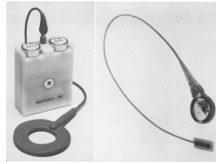
C. NORMAN SHEALY, M.D.*
J. THOMAS MORTIMER, M.S.*
JAMES B. RESWICK, D.Sc.†

ABOUT THE AUTHORS

* C. Norman Shealy, M.D., is Chief of Neurosurgery, Cleveland Clinic, La Crosse, Wisconsin, and Assistant Clinical Professor of Neurosurgery, University of Wisconsin, Madison. He graduated in 1959 from Duke University Medical School, Durham, North Carolina, interned at Case University, and served as faculty at Harvard Medical School, St. Louis, Missouri, and at Massachusetts General Hospital, Boston. Special honors received by Dr. Shealy include the First Annual Harold G. Wolff M.D. Award and a Honorary Award for Best Undergraduate Research.

* J. Thomas Mortimer, M.S., is a graduate of Texas Technical College, Lubbock, Texas, holds the M.S. degree from Case Institute of Technology, Cleveland, Ohio, and is currently a candidate for a Ph.D. at Case. His interests are biomedical engineering and electronics.

† James B. Reswick, D.Sc., is Professor of Engineering at the Case Institute of Technology, Cleveland, Ohio, and since 1960 has been Director of the Engineering Center in Case Institute.



Neuromodulation Today



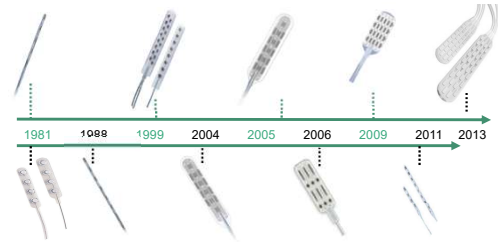
- 1) Significant Pain Reduction
- 2) Non-Opioid Pain Management
- 3) Customizable and Adjustable Pain Relief
- 4) Minimally Invasive Procedure
- 5) Reversible Treatment Option
- 6) Long-Term Pain Relief
- 7) Improved Quality of Life
- 8) Enhanced Mobility and Functionality
- 9) Minimal Side Effects Compared to Medications
- 10) Effective for Multiple Chronic Pain Conditions



Neuromodulation Devices



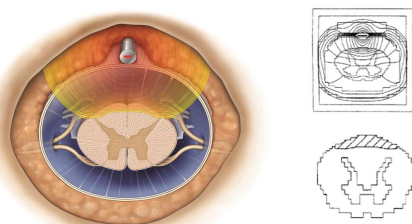
Neuromodulation Devices



Electrodes: 4 contacts → 8 contacts → 16 contacts → 20 (16) contacts → 32 contacts



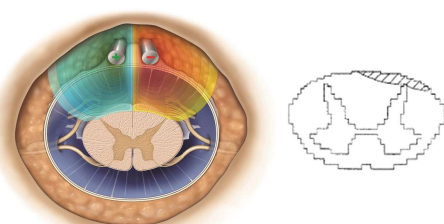
Neuromodulation Today



Single column



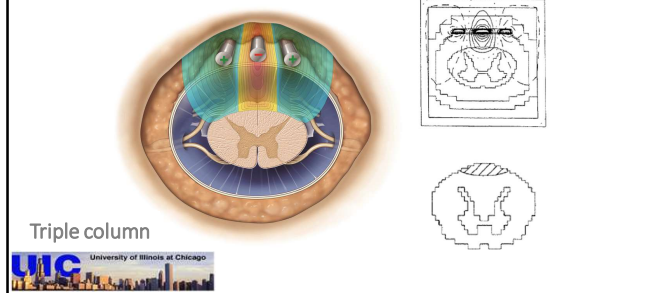
Neuromodulation Today



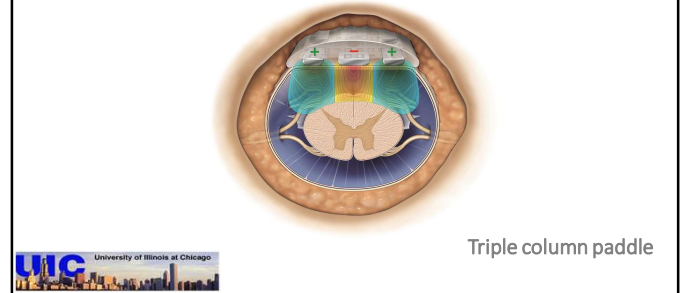
Double column



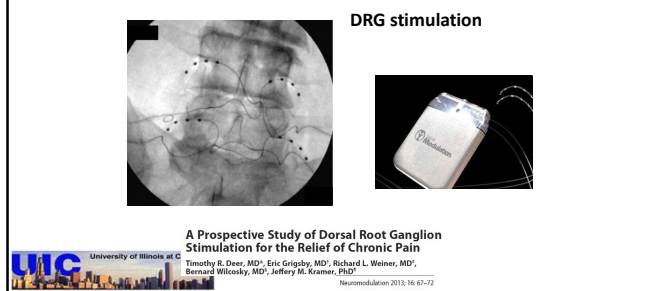
Neuromodulation Today



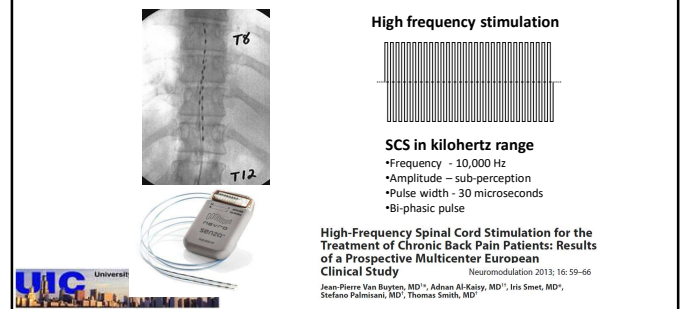
Neuromodulation Today



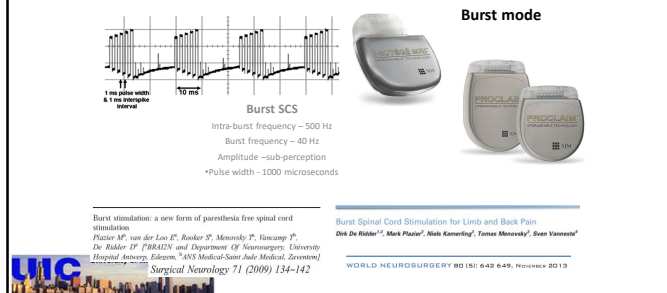
New in Neuromodulation



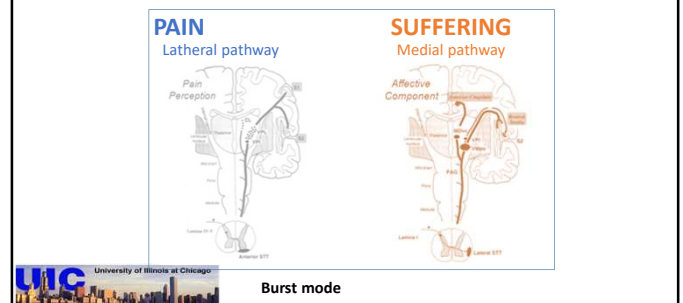
New in Neuromodulation



New in Neuromodulation

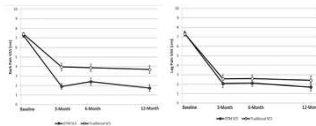


New in Neuromodulation



New in Neuromodulation

DTM ("differential target multiplexed") stimulation – proprietary "innovative programming strategy"



Twelve-Month results from multicenter, open-label, randomized controlled clinical trial comparing differential target multiplexed spinal cord stimulation and traditional spinal cord stimulation in subjects with chronic intractable back pain and leg pain

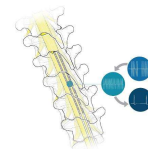
Michael Edelman MD, MBA¹ | Harold Coughlin MD² | Rafael Jazini MD³
David Perreault MD⁴ | Christopher Merrill MD⁵ | Brett Shah MD⁶ | Julian Noriega MD⁷
Philip Kim MD⁸ | Aaron Calabrese MD⁹ | Jonathan Carlson MD¹⁰ | Richard Brutsche MD¹¹
Nicholas Sengul MD¹² | Nigel Vignati MD¹³ | Ronald Maly MD, PhD¹⁴
¹University of Illinois at Chicago, ²University of Michigan, ³University of Texas at Dallas, ⁴University of California, ⁵University of Colorado, ⁶University of Florida, ⁷University of Georgia, ⁸University of Illinois at Chicago, ⁹University of Iowa, ¹⁰University of Kentucky, ¹¹University of Maryland, ¹²University of Minnesota, ¹³University of North Carolina, ¹⁴University of South Florida

Pain Practice. 2021;21:912-923.



New in Neuromodulation

Sub-perception SCS: paresthesia-free stimulation paradigm



Outcomes of a Multicenter, Prospective, Crossover, Randomized Controlled Trial Evaluating Subperception Spinal Cord Stimulation at ≤1.2 kHz in Previously Implanted Subjects

James North, MD¹, Eric Lounders, MD², Albert Lee, MD³,
Jared Neuhoff, MD⁴, Christopher Kozlowski, MD⁵,
Edward Wachsberg, MD⁶, Samir Sheth, MD⁷, Joseph Sweeney, MD⁸,
Nigel Vignati, MD, PhD⁹, Benjamin Lammert, MD¹⁰,
Thomas Vavrovec, MD, PhD¹¹, Erik Shaw, MD¹², Joseph Attalah, MD¹³,
David McKeown, MD¹⁴, John Kim, MD¹⁵, Cong Yu, MD¹⁶,
Joseph Hwang, MD¹⁷, John G. Coates, MD¹⁸, John F. Vavrovec, MD¹⁹,
Joseph Hwang, MD²⁰, Nathan Miller, MD²¹, Li-Li Chen, MD²²,
Roshni Jain, MD²³

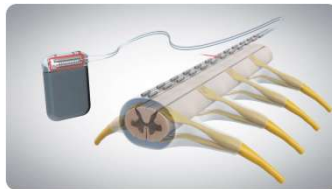
Neuromodulation 2020; 23: 102-108



New in Neuromodulation

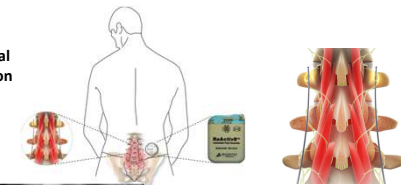
Closed loop approach

Real time therapy adjustment based on evoked compound action potentials



New in Neuromodulation

Extraspinal stimulation



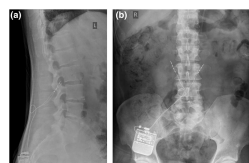
Chronic Low Back Pain: Restoration of Dynamic Stability
Neuromodulation 2015; 18: 478-486

Kristiaan Deckers, MD¹, Kris De Smedt, MD², Jean-Pierre van Beylen, MD³,
Ivo Smet, MD⁴, Sam Eladad, MD⁵, Rahim Gulati, MD⁶, Geertman Barnardhorst, MD⁷,
Joel de Rudder, MD, PhD⁸, Chris Gilligan, MD⁹, Kristian Jans, MD, PhD¹⁰,
Jan Peter Heeremans, MD¹¹, Peter Crosby, MD¹²



New in Neuromodulation

Extraspinal stimulation



New Therapy for Refractory Chronic Mechanical Low Back Pain—Restorative Neurostimulation to Activate the Lumbar Multifidus: One Year Results of a Prospective Multicenter Clinical Trial

Kristiaan Deckers, MD¹, Kris De Smedt, MD², Bruce Mitchell, MD³,
David Vriens, MD⁴, Marc Buijs, MD⁵, Peter Georgiev, MD⁶,
Matthew Green, MD⁷, John Vriens, MD⁸, Sam Eladad, MD⁹,
Arieh Jansen, MD¹⁰, Jean-Pierre van Beylen, MD¹¹, Ivo Smet, MD¹²,
Virek Mahla, MD¹³, Shankar Ramaswamy, MD¹⁴,
Geertman Barnardhorst, MD¹⁵, Richard Tubbens, MD¹⁶, Robert Gassio, MD¹⁷,
James Rathmell, MD¹⁸, Chris Gilligan, MD¹⁹

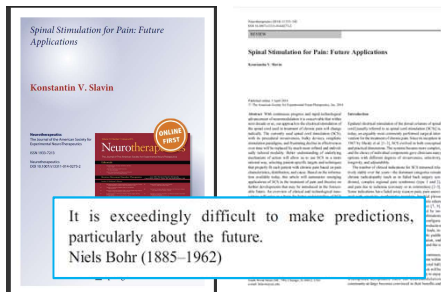


Prospective (*) controlled (#) randomized (^) multi-center (!) studies:

1. **Accurate** (Spinal Modulation / Abbott) *#!
DRG stimulation – compared to conventional SCS
2. **SENZA** (Nevro) *#!
High-frequency SCS – compared to conventional SCS
3. **SUNBURST** (St. Jude Medical / Abbott) *#!
Burst SCS – compared to conventional SCS
4. **HD SCS** (Medtronic) *
High-density SCS (after failed conventional SCS)
5. **SubPSCS** (Boston Scientific) *!
Sub-perception SCS (in successful conventional SCS)
6. **PROCO** (Boston Scientific) *#!
Comparative assessment of different high frequencies
7. **EVOKE** (Saluda) *#!
Comparative analysis of closed loop vs. open loop SCS
8. **AVALON** (Saluda) *!
Closed-loop stimulation – open label study
9. **DTM** (Medtronic) *#!
Differential target multiplexed vs. conventional SCS
10. **BENEFIT 1-2-3** (Biotronik) *!
Multi-phase evaluation of new system



Future of neuromodulation for pain



It is exceedingly difficult to make predictions, particularly about the future.
Niels Bohr (1885–1962)

Future of neuromodulation for pain

Long-distance programming?



Telemedicine programming

Future of neuromodulation for pain

Non-invasive neuromodulation?



FDA-approved devices

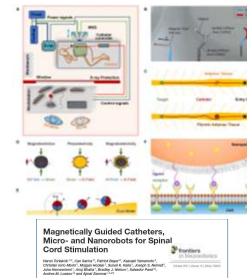


At-Home Cortical Stimulation for Neuropathic Pain: a Feasibility Study with Initial Clinical Results
Neurotherapeutics (2019) 16:1198–1209
Luis Garcia-Lamoa^{1,2} · Caroline Perchet¹ · Kaichi Hagiwara¹ · Nathalie Andre-Obadia^{1,2}

Future of neuromodulation for pain

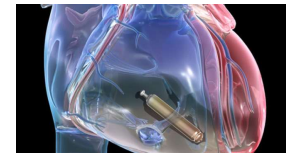
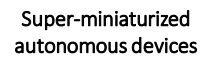
Magnetic guidance?

Robotics?



Future of neuromodulation for pain

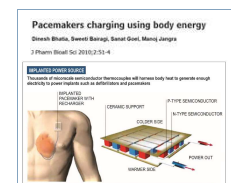
Super-miniaturization



Future of neuromodulation for pain

No need in recharging!

Body-heat powered devices



Future of neuromodulation for pain

Optic fibers instead of metal wires?

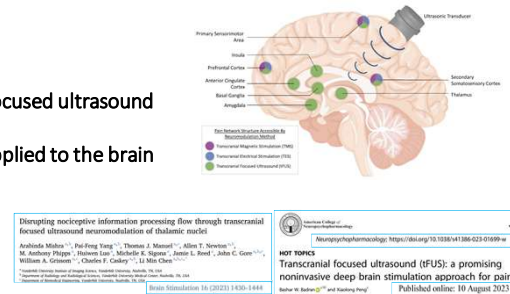
Photovoltaic electrical neurostimulation



Future of neuromodulation for pain

Non-electrical modulation?

Focused ultrasound applied to the brain



Focused ultrasound applied to the nerves



Thermal neuromodulation

