

Neuromodulation: an overview

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Declaration of conflict of interest





I have no potential conflicts of interest to report

Objectives

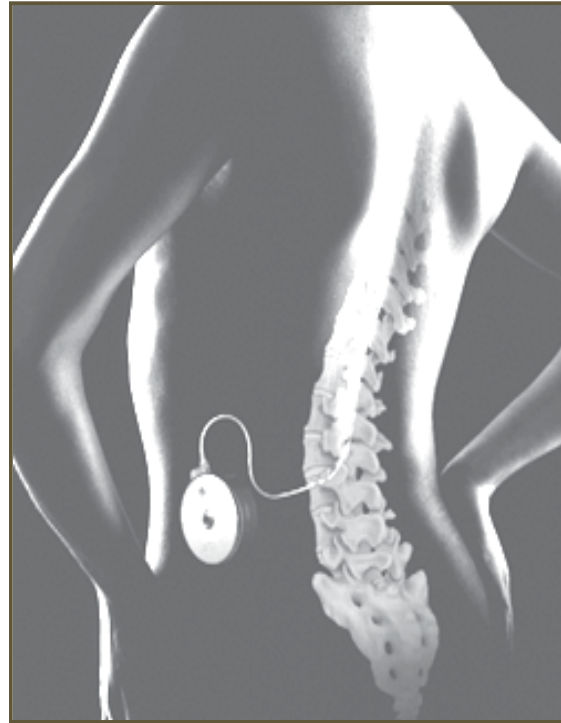
By the end of this lecture participants will be able to:

- Describe main technologies involved in neuromodulation for pain
- List the indications and contraindications of neuromodulation
- Identify strategies to improve long-term SCS success

Neuromodulation

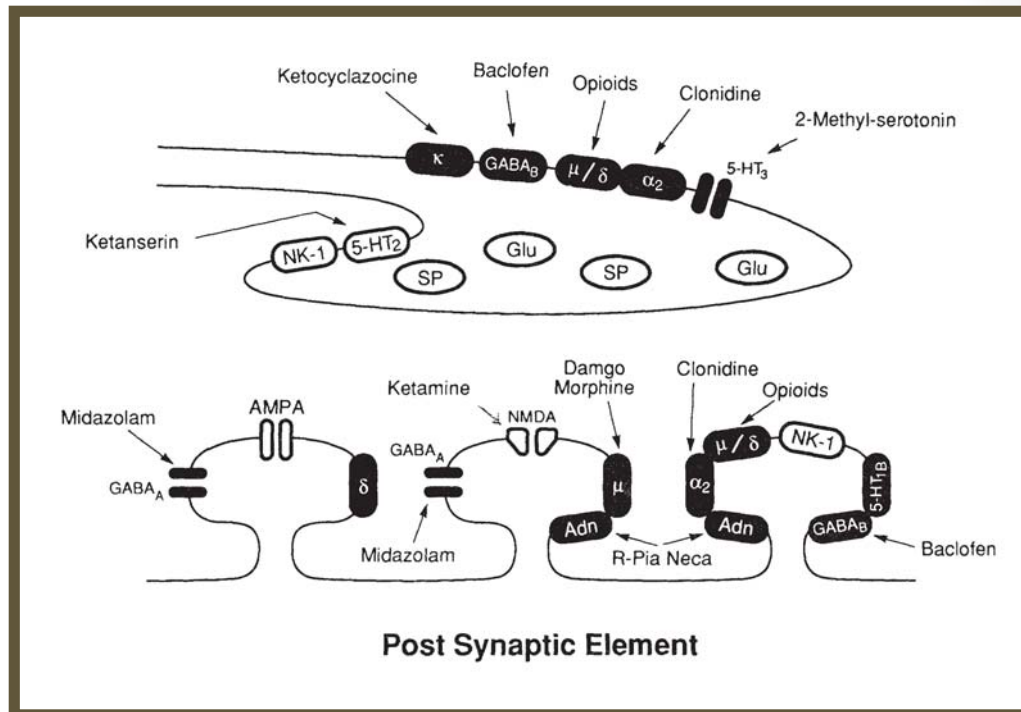
- Intrathecal pump 
- Spinal stimulation 
- Peripheral stimulation (GNO) 
- Deep brain stimulation 
- Sacral nerve stimulation

Intrathecal drug delivery



Medtronic

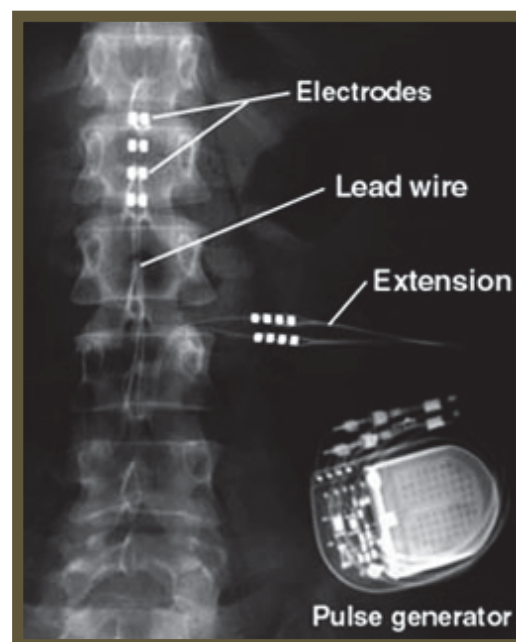
Intrathecal drug receptors



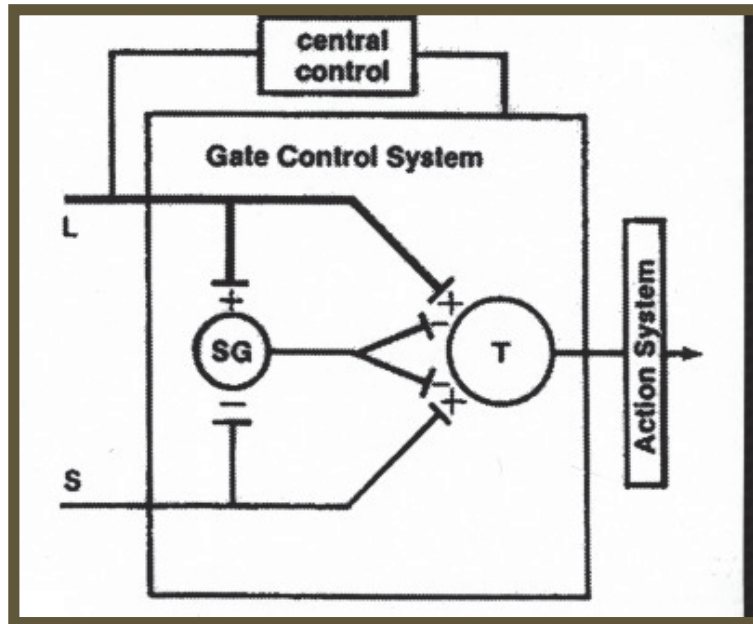
Intrathecal analgesia

- opioids
 - morphine
 - hydromorphone
 - fentanyl
 - sufentanil
- alpha-2 adrenergic
 - clonidine
 - dexmedetomidine
- bupivacaine
- ziconotide

Spinal stimulation



Gate control theory



Wall & Melzack

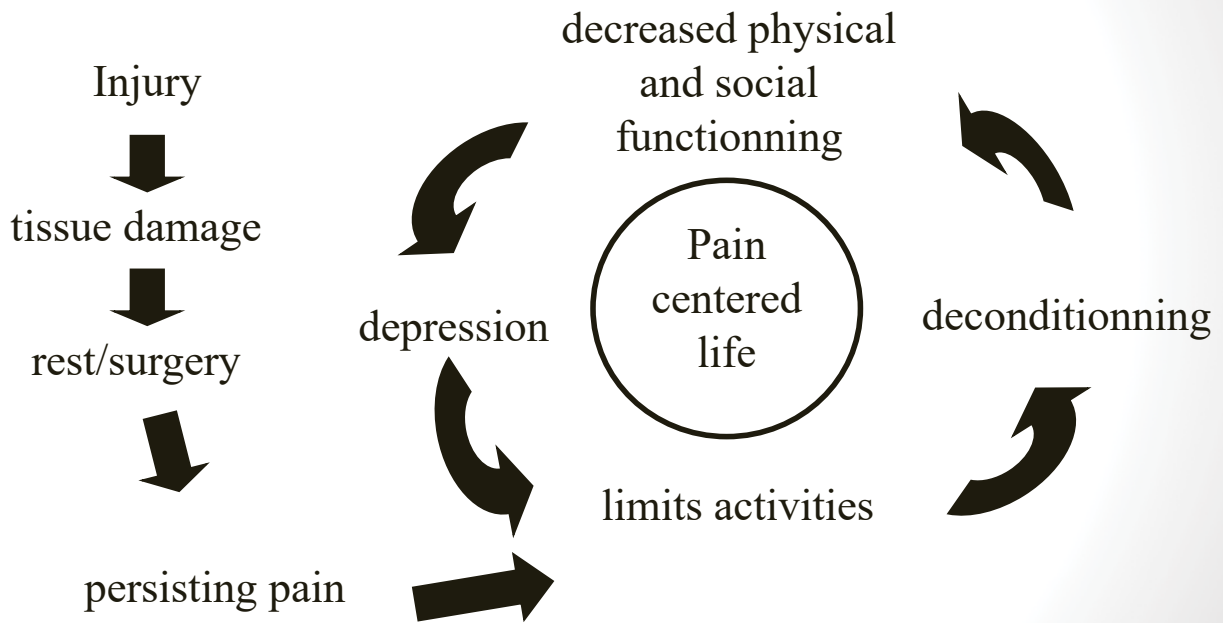
Spinal stimulation

Mechanism of action:

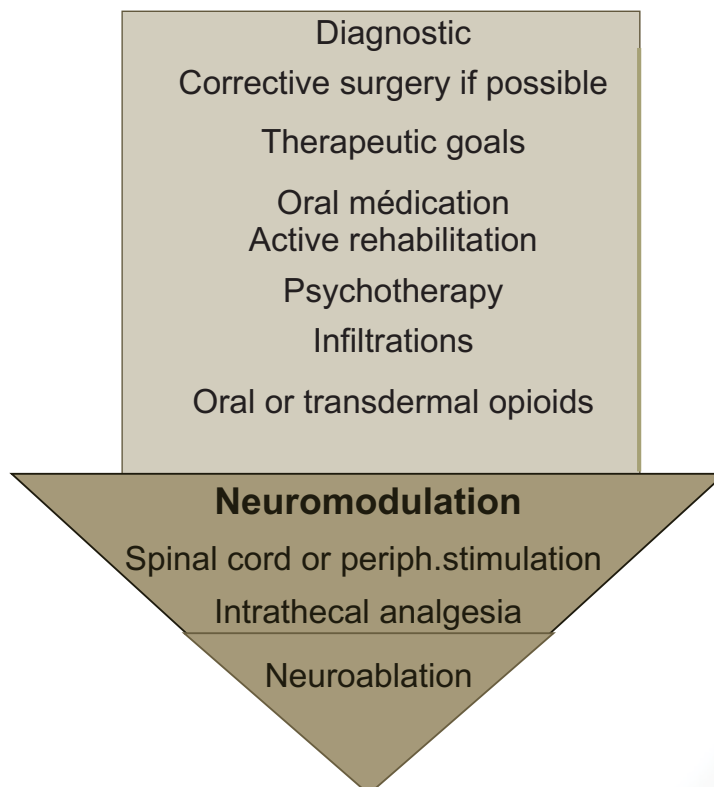
- antidromic activation of spinal afferent neurons
- alteration of pain transmission pathways
- inhibitory neurotransmitter (GABA) release
- activation of descending inhibitory fibers
- inhibition of sympathetic efferents
- modulation of glial cells activation

Krames 1999, R Vallejo 2017, Heijmans 2020

Pain spiral



Approaches to chronic pain management



Path of a referred patient for neuromodulation

1. Patient selection
2. Trial phase (first phase)
3. Permanent implantation (second phase)
4. Follow up

Path of a referred patient for neuromodulation

- 1. Patient selection**
 - **Medical assesment**
 - **Source of pain**
 - **Cure?**
 - **Review of medications/infiltrations**
 - **Contraindications**
 - **Psychological assessment**
 - **Contraindications**
2. Trial phase (first phase)
3. Permanent implantation (second phase)
4. Follow up

Path of a referred patient for neuromodulation

1. Patient selection

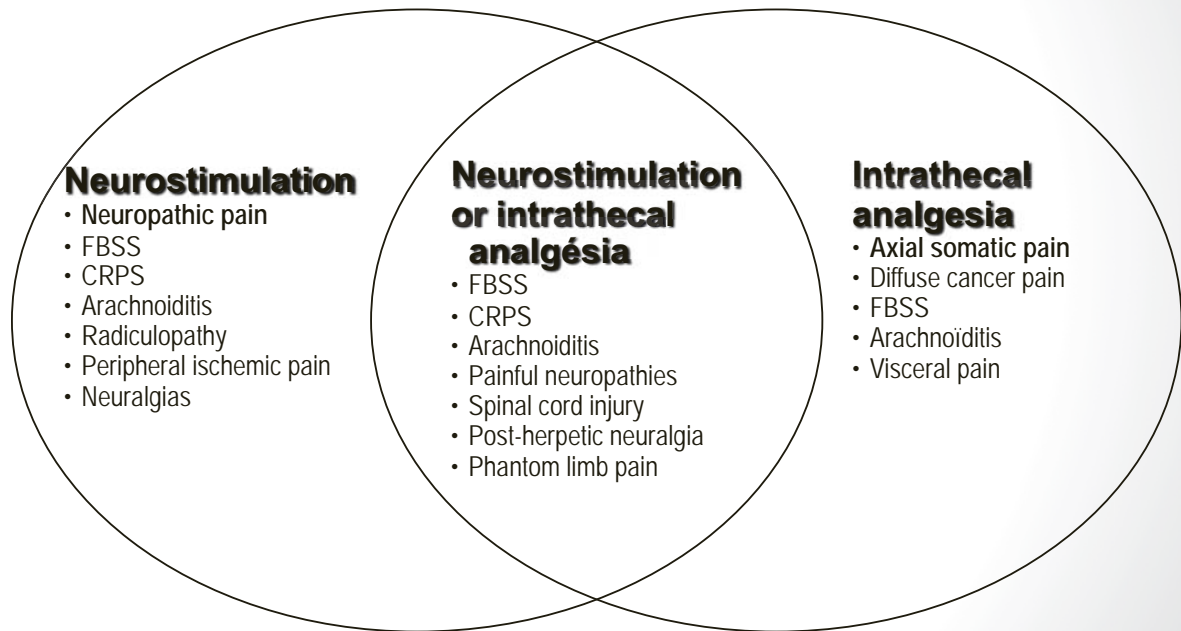
- **Medical assesment**
 - **Contraindications:**
 - Sepsis
 - Coagulopathy
 - Other painful pathology
 - Anatomy or sequelae making it impossible to position the probes (fusion / instrumentation)
 - **Psychological assessment**
2. Trial phase (first phase)
 3. Permanent implantation (second phase)
 4. Follow up

Path of a referred patient for neuromodulation

1. Patient selection

- **Medical assesment**
 - **Psychological assessment**
 - **Contraindications**
 - Untreated drug addiction
 - Uncontrolled mental disorder (anxiety, depression, catastrophizing, post-traumatic stress disorder)
 - Suicidal patient
 - Personality disorder
 - Inability to understand the procedure and its implication
 - Litigation
2. Trial phase (first phase)
 3. Permanent Permanent implantation (second phase)
 4. Follow up

Indications for neuromodulation



Krames E. Intervent Pain Manage, 1996

Spinal stimulation Randomized controlled studies

Study	Comparison group	Follow up	Pain relief	Medication	Other benefits
Kumar & al 2008	SM + GMC vs GMC	2 years	- LL significant pain relief -Satisfaction: 47 % SM + GMC vs 7 % GMC	No change	Better physical condition, better quality of life
North & al 2005	SM vs reopération	3 years	Relief > 50 % 47 % SM vs 12 % reoperation	More opioids in reoperation group	Loss of function in reoperation group
Kemler 2008	SM + PT vs PT	5 years	Decreased VAS av. 1.7 (SM + PT) vs 1.0 (PT only)		No significant difference
Manca 2008	SM + GMC vs GMC	6 months		Less médication in SM + GMC	Better quality of life in SM + GMC

Spinal stimulation

Neuropathic pain :

- Fail back surgery syndrome (FBSS)
- Chronic regional pain syndrome (CRPS)

Ischemic pain :

- Refractory angina pectoris
- Critical lower limb ischemia

INESSS 2013

Path of a referred patient for neuromodulation

1. Patient selection
2. **Trial phase (first phase)**
3. Permanent implantation (second phase)
4. Follow up

Trial phase



Medtronic



Spinal stimulation programmation



- choice of cathodes and anodes
- amplitude
- pulse width
- frequency

Path of a referred patient for neuromodulation

1. Patient selection
2. Trial phase (first phase)
3. **Permanent implantation (second phase)**
4. Follow up

Spinal stimulation postoperative instructions

Restrictions

- avoid for 6 to 8 weeks
 - trunk bending, extension, twisting
 - lift up 5 pounds or more
 - raise hands above their head
 - not sleep on the belly
- avoid driving for the next 2 weeks
- no housekeeping for the first week
- no sexual activity for the first week

Spinal stimulation postoperative instructions

Activities

- gradually begin to resume normal activities
- encourage walking
 - short distance for 1 to 2 weeks
 - Increase progressively then

Path of a referred patient for neuromodulation

1. Patient selection
2. Trial phase (first phase)
3. Permanent implantation (second phase)
4. **Follow up**

Intrathecal drug delivery system complications

- related to drugs
 - Opioids (N/V, constipation, sedation, pruritus, resp. depression)
 - Clonidine (sedation, hypotension)
 - Bupivacaine (hypotension)
 - Ziconotide (not available in Canada)
- related to procedures
 - infection
 - hematoma
 - cerebrospinal fluid leak
- related to drug delivery device
 - catheter (migration, break, disconnection, obstruction, granuloma)
 - pump dysfunction (rare)
- drug overdose, withdrawal

Delhaas 2020

La neurostimulation

Tableau 1. Spinal cord stimulation indications and complications

Diagnostic	Trial	Implant (%)	Infection	Lead migration	Lead connection failure	Lead breakage	IPG pain
SDRC							
Type 1	317	251 (79)	11(3.4)				
Type 2	28	24 (83)	1(3.5)				
FBSS	235	176 (75)	15 (6.3)				
MVAS	20	13 (65)	0 (0)				
Douleur viscérale	37	29 (78)	1 (2.3)				
Neuropathie	70	57 (81)	4 (5.7)				
Total	707	527 (75)	32 (4.5)	119 (22.6)	50 (9.5)	33 (6)	86 (12)

Mekhail & al Pain Practice 2011

Spinal stimulation

Causes of failure

- undiagnosed psychological disorder
- development of diffuse pain
- back pain
- undesired stimulation
- positional stimulation
- tolerance

Spinal stimulation

Causes of failure

- undiagnosed psychological disorder
- development of diffuse pain
- back pain
 - paresthesia free stimulation
- undesired stimulation
 - DRG stimulation
 - paresthesia free stimulation
- positional stimulation
 - paresthesia free stimulation, adaptive stimulation
- tolerance
 - paresthesia free stimulation

New spinal stimulation

Paresthesia free stimulation

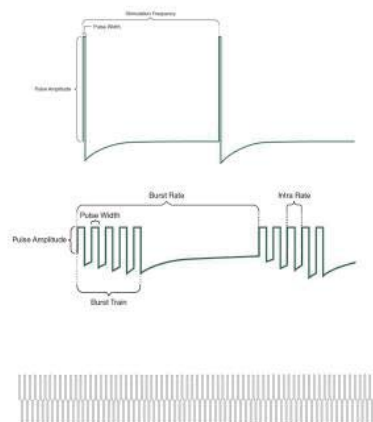
- High frequency stimulation
- High density stimulation
- Burst stimulation

Other

- closed-loop SCS
- Differential Target Multiplexed (DTM)

Spinal stimulation

SPINAL CORD STIMULATION WAVEFORMS



Traditional Tonic

- Relatively low energy
- Recharge every 1-2 months

Burst Stimulation

- Parameters within traditional ranges
- Low-moderate energy
- Average recharge similar to tonic
- Device provides both tonic & burst¹

High Frequency Stimulation

- Parameters outside the traditional ranges
- Highest energy, daily recharge
- Device only provides tonic stimulation at programmable frequencies (up to 10,000hz)²
- Reduced projected device life compared to traditional tonic²

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1 Prodigy™ Clinician Manual, referenced 5/5/2014
2 Nevro Corp. 10186-ENG-Physician Manual Rev G, 2012, Menlo Park, CA, USA



Article

Sub-Perception and Supra-Perception Spinal Cord Stimulation in Chronic Pain Syndrome: A Randomized, Semi-Double-Blind, Crossover, Placebo-Controlled Trial

Paweł Sokal^{1,2,*}, Agnieszka Malukiewicz¹, Sara Kierońska¹, Joanna Murawska³, Cezary Guzowski³, Marcin Rudaś¹, Dariusz Paczkowski¹, Marcin Rusinek¹ and Mateusz Krakowiak¹

Neuromodulation: Technology at the Neural Interface

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Success Using Neuromodulation With BURST (SUNBURST) Study: Results From a Prospective, Randomized Controlled Trial Using a Novel Burst Waveform

Timothy Deer, MD*[†]; Konstantin V. Slavin, MD[†]; Kasra Amirdelfan, MD*[‡]; Richard B. North, MD[§]; Allen W. Burton, MD[¶]

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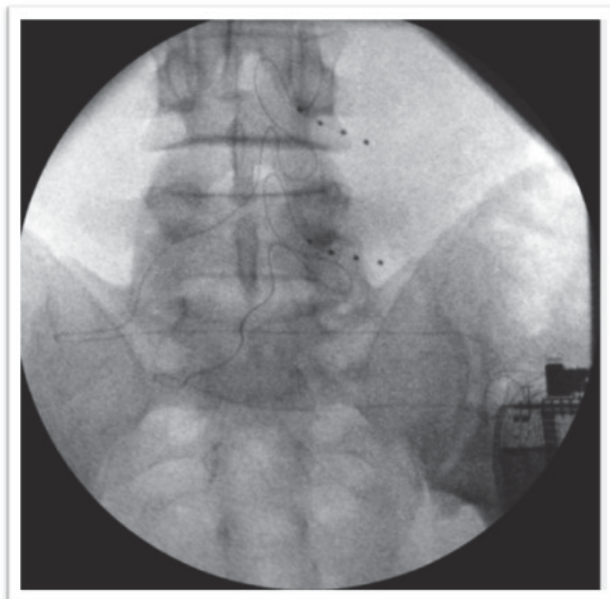
Bradford E. Gliner, MS[¶]

Ricardo Vallejo, MD, PhD^{||}

B. Todd Sitzman, MD, MPH[#]

Comparison of 10-kHz High-Frequency and Traditional Low-Frequency Spinal Cord Stimulation for the Treatment of Chronic Back and Leg Pain: 24-Month Results From a Multicenter, Randomized, Controlled Pivotal Trial

Dorsal Root Ganglion stimulation



Conclusion

The key to success:

- carry out a good biopsychosocial assessment
- look for a clear source of pain
- clarify expectations
- conduct a trial stimulation period
- try different modes of stimulation
- provide systematic follow up



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