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# Spinal cord stimulation in neuropathic spinal cord injury pain

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Centre for Pain Medicine, Nottwil

6th International Symposium „Invasive Procedures in Motion“  
2/3 March 2018



# Disclosures



# Agenda



- Spinal Cord Stimulation (SCS) / Neuromodulation
- Neuropathic spinal cord injury pain
- SCS in neuropathic spinal cord injury pain – literature
- Two cases

# Neuromodulation



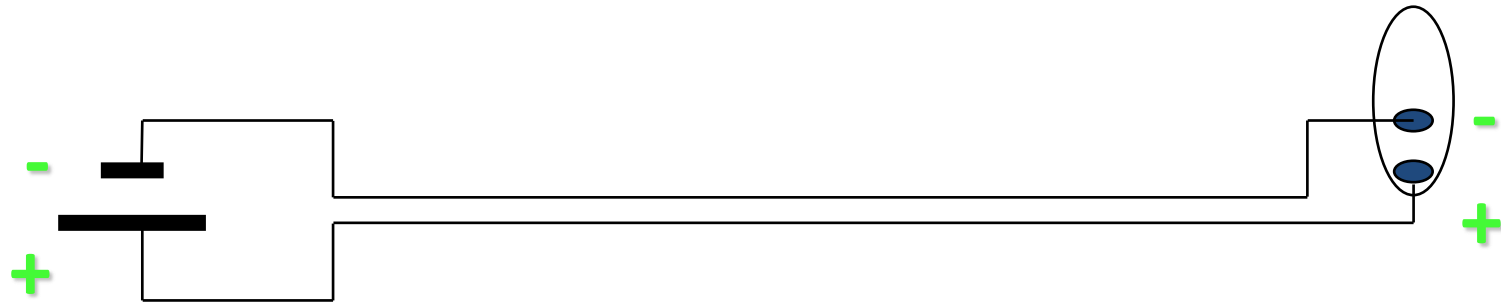
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*...a technology that acts directly upon nerves. It is the alteration or modulation of nerve activity by delivering electrical or pharmaceutical agents to a target area...*

- Electrical- / Neurostimulation of the dorsal column (SCS)
- Intrathecal Drug Delivery
- Neuromodulation is used in a variety of clinical situations

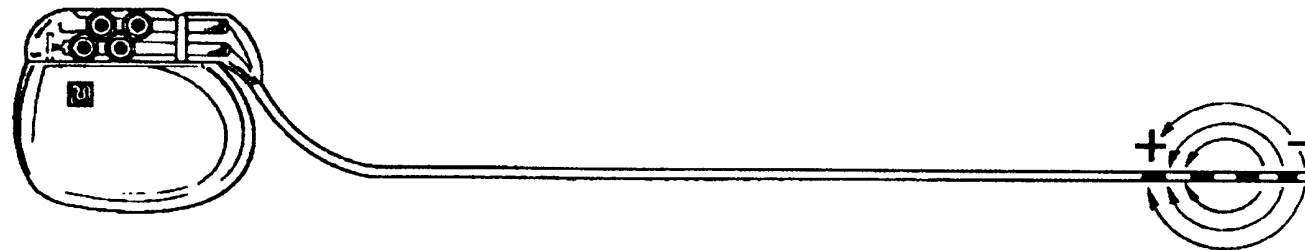
# Spinal Cord Stimulation: a set of cable and a pulse generator



Pulse Generator

Cable

Electrode



## **Electrical Inhibition of Pain by Stimulation of the Dorsal Columns:**

*Preliminary Clinical Report*

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

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

- Abdominal and chest pain due to metastases of a lung carcinoma
- Epidural electrode at Th3
- Pain reducing effect for 1½ days

# Spinal Cord Stimulation



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SCS: a well established method

First tonic stimulation

## CLINICAL TRIAL

Kumar K, Taylor RS, Jaques L, et al.: Neurosurgery 63 (2008): 762-770

### THE EFFECTS OF SPINAL CORD STIMULATION IN NEUROPATHIC PAIN ARE SUSTAINED: A 24-MONTH FOLLOW-UP OF THE PROSPECTIVE RANDOMIZED CONTROLLED MULTICENTER TRIAL OF THE EFFECTIVENESS OF SPINAL CORD STIMULATION

- 2- year follow up of 42 patients with SCS in failed back surgery syndrome
- Significant reduction in leg pain
- Improved quality of life
- Improved functional capacity



# Spinal Cord Stimulation



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Later: High frequency stimulation or burst stimulation

## RESEARCH—HUMAN—CLINICAL TRIALS

Kapural L, Yu C, Doust MW, et al.: *Neurosurgery* 0 (2016): 1-10

### **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**

- 171 patients with SCS (90 HF, 81 low-frequency) with back and leg pain
- 2-year follow up
- Better outcome for both back and leg pain





One parameter? Multiple parameters? Intensity-dependent?

Neuromodulation: Technology at the Neural Interface

Received: April 15, 2016   Revised: August 1, 2016   Accepted: August 23, 2016

(onlinelibrary.wiley.com) DOI: 10.1111/ner.12529

## **Altering Conventional to High Density Spinal Cord Stimulation: An Energy Dose-Response Relationship in Neuropathic Pain Therapy**

**Frank Wille, MD\*<sup>†</sup>; Jennifer S. Breel, MPA\*<sup>†</sup>; Eric W.P. Bakker, PhD<sup>‡</sup>;  
Markus W. Hollmann, MD, PhD<sup>†</sup>**

- 30 patients with insufficient effect of a conventional SCS therapy
- High density stimulation (30 → 400 Hz, 300 → 400 mcs): density more than tenfold
- 12-months follow up
- Significant better pain reduction

One parameter? Multiple parameters? Intensity-dependent?

## Effects of Rate on Analgesia in Kilohertz Frequency Spinal Cord Stimulation: Results of the PROCO Randomized Controlled Trial

Simon J. Thomson, MBBS<sup>\*</sup>; Moein Tavakkolizadeh, MD<sup>†</sup>;  
Sarah Love-Jones, MBBS<sup>‡</sup>; Nikunj K. Patel, MD<sup>§</sup>; Jianwen Wendy Gu, PhD<sup>¶</sup>;  
Amarpreet Bains, PhD<sup>\*\*</sup>; Que Doan, BS<sup>¶</sup>; Michael Moffitt, PhD<sup>¶</sup>

Neuromodulation 2018; 21: 67–76

- 20 patients with a pain reduction with high-frequency stimulation (10 kHz) are tested for other frequencies (1, 4, 7 kHz)
- Pain reduction is depending on all three parameters (frequency, pulse width, amplitude)

# Neuropathic Spinal Cord Injury Pain



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- Neuropathic pain is a common problem in paraplegia and tetraplegia

- Prevalence > 50%

**EJP**

European Journal of Pain

REVIEW ARTICLE

**Neuropathic pain prevalence following spinal cord injury: A systematic review and meta-analysis**

D. Burke<sup>1</sup>, B.M. Fullen<sup>1,2</sup>, D. Stokes<sup>3</sup>, O. Lennon<sup>1</sup>

- «Pain arising as a direct consequence of a lesion or disease of the somatosensory system» (Treede 2008)
- One of the most distressing and disabling complications
- Appears to be persistent despite various treatments, treatment is difficult and often inadequate
- Pharmacological, interventional, psychological approaches



# Neuropathic Spinal Cord Injury Pain



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Anesthesiology 2010; 113:1392-1405

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## Spinal Cord Stimulation-induced Analgesia

### *Electrical Stimulation of Dorsal Column and Dorsal Roots Attenuates Dorsal Horn Neuronal Excitability in Neuropathic Rats*

Yun Guan, M.D., Ph.D.,\* Paul W. Wacnik, Ph.D.,† Fei Yang, Ph.D.,‡ Alene F. Carteret, M.S.,§  
Chih-Yang Chung, M.D.,‡ Richard A. Meyer, M.S.,|| Srinivasa N. Raja, M.D.#

- Basis is the knowledge about the wind-up phenomenon of WDR neurons cranial to a lesion of the spinal cord
- Guan (2010): SCS is capable to attenuate dorsal horn neuronal excitability in nerve-injured rats  
L5 injury, tonic stimulation with 50 Hz and 200 mcs → reduction of the activity rate of WDR neurons
- In vivo model that gives an important insight in cellular mechanisms underlying SCS analgesia



# Neuropathic Spinal Cord Injury Pain



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Research Paper

**PAIN**

March 2015 • Volume 156 • Number 3



## **Spinal cord stimulation attenuates temporal summation in patients with neuropathic pain**

Elon Eisenberg<sup>a,b,\*</sup>, Yulia Burstein<sup>c</sup>, Erica Suzan<sup>a</sup>, Roi Treister<sup>d</sup>, Joshua Aviram<sup>e</sup>

- 18 patients with radicular leg pain
- Effect of SCS on temporal summation (TS, the clinical correlate of the wind-up phenomenon)
- TS of the most painful site of the affected leg versus the contralateral leg
- SCS therapy «ON» and «OFF»
- Decrease of the magnitude of TS in the painful leg, no SCS effect on TS in the non-affected leg

→ Reproducing the findings of the animal model in humans





J Neurosurg 82:35–39, 1995

## Spinal cord stimulation in the treatment of paraplegic pain

BEATRICE CIONI, M.D., MARIO MEGLIO, M.D., LUIGI PENTIMALLI, M.D.,  
AND MASSIMILIANO VISOCCHI, M.D.

*Istituto di Neurochirurgia, Università Cattolica, Rome, Italy*

- 25 patients with SCI pain (5 tetraplegic, 20 paraplegic, 6 complete, 19 incomplete)
- SCS: one percutaneous electrode (17 patients above, 8 patients below the lesion)
- Paresthesia in the painful area (22 patients)
- 9 patients implanted (>50% pain reduction), sufficient pain relief after 37 months
- SCS was more successful in incomplete paraplegia
  
- Lacking quite a few details about the population as well as the treatment itself

# Literature about SCS in neuropathic SCI Pain



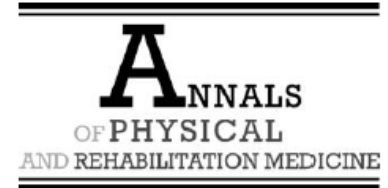
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Disponible en ligne sur  
 ScienceDirect  
www.sciencedirect.com

Elsevier Masson France  
 EM|consulte  
www.em-consulte.com

Annals of Physical and Rehabilitation Medicine 52 (2009) 180–187



Update article / Mise au point

The chronic neuropathic pain of spinal cord injury:  
Which efficiency of neuropathics stimulations?

D. Lagauche<sup>a,\*</sup>, J. Facione<sup>a</sup>, T. Albert<sup>b</sup>, C. Fattal<sup>c</sup>

- Review: statement of the efficacy of SCS in neuropathic spinal cord injury pain
- 27 publications about SCS with at least one patient with spinal cord injury
- Problem: quality of the studies
- 21/27 studies patients with neuropathic SCI pain put together with patients with other neuropathic pain



# Literature about SCS in neuropathic SCI Pain



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Neurochirurgie. 1995;41(2):73-86; discussion 87-8.

## [Chronic spinal cord stimulation in the treatment of neurogenic pain. Cooperative and retrospective study on 20 years of follow-up].

[Article in French]

Lazorthes Y<sup>1</sup>, Siegfried J, Verdie JC, Casaux J.

TABLEAU X. – *Pourcentage de succès dans les douleurs neurogènes secondaires*  
The success rate for spinal cord injury

	1972-1977		1978-1983		1983-1990	TOTAL (1972-1990)	
	Z	T	Z	T		Z	T
	(n) 101 patients	(1)	(3)	(38)		(7)	(48)
A court terme	100 %	66 %	56 %	50 %	60 %	58 %	50 %
A long terme	0 %	33 %	29 %	33 %	40 %	34 %	34 %

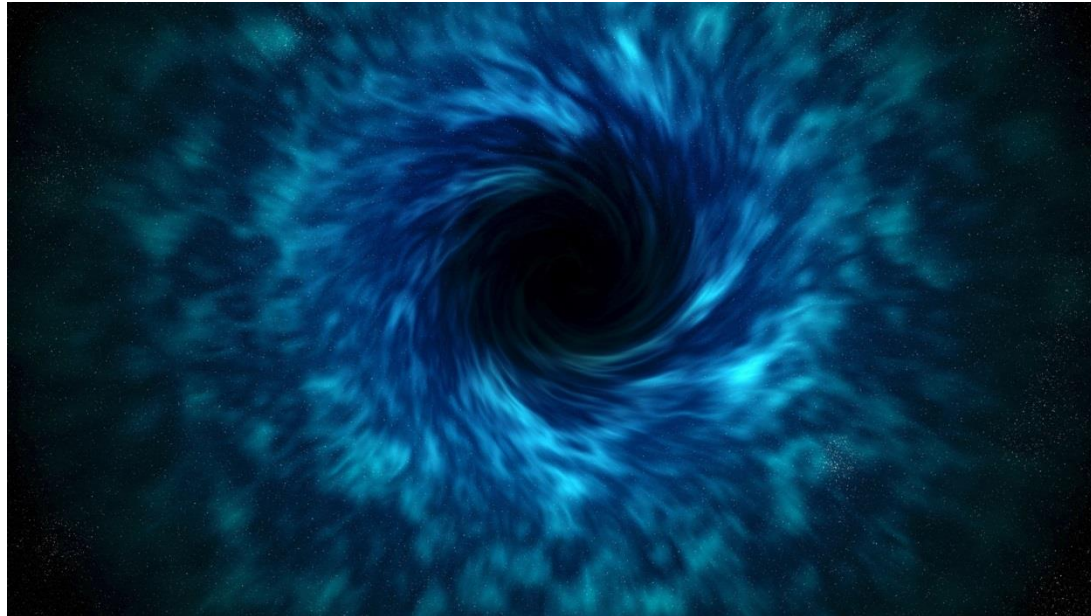
- Retrospective evaluation of 101 patients with SCS therapy for a neurogenic pain due to a lesion of the spinal cord
- Period of 20 years in two study sites
- No further description of the pain (localization, character, intensity) or the nature of the spinal cord lesion
- Success of therapy: percentage of improvement of pain
- Long term (min. 2 years) success rate in both study sites at 34% improvement of pain



# Literature about SCS in neuropathic SCI Pain



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- Case reports
- Mixed populations

→ prospective clinical trials with more homogeneous populations

# Literature about SCS in neuropathic SCI Pain



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Spinal Cord (2016) 54, S14–S23  
Official Journal of the International Spinal Cord Society  
www.nature.com/sc

## GUIDELINES

### The CanPain SCI Clinical Practice Guidelines for Rehabilitation Management of Neuropathic Pain after Spinal Cord: Recommendations for treatment

SD Guy<sup>1,2</sup>, S Mehta<sup>1,2</sup>, A Casalino<sup>3</sup>, I Côté<sup>4</sup>, A Kras-Dupuis<sup>3</sup>, DE Moulin<sup>2,5</sup>, AG Parrent<sup>2,6</sup>, P Potter<sup>2,3</sup>, C Short<sup>7</sup>, R Teasell<sup>1,2,3</sup>, CL Bradbury<sup>8</sup>, TN Bryce<sup>9</sup>, BC Craven<sup>8</sup>, NB Finnerup<sup>10</sup>, D Harvey<sup>11</sup>, SL Hitzig<sup>8,12</sup>, B Lau<sup>13</sup>, JW Middleton<sup>14</sup>, C O'Connell<sup>15,16</sup>, S Orenczuk<sup>3</sup>, PJ Siddall<sup>14</sup>, A Townson<sup>13</sup>, C Truchon<sup>17</sup>, E Widerström-Noga<sup>18</sup>, D Wolfe<sup>1,3</sup> and E Loh<sup>1,2,3</sup>

- SCS is mentioned
- So far no clear recommendation

## THERAPIES REQUIRING FURTHER RESEARCH

*Spinal cord stimulation.* A case series with a mixed pain population of patients with SCI presented no statistically significant data on pain intensity reduction.<sup>50</sup>

*Hypnotic suggestion.* An RCT found a reduction in intensity of SCI-related NP after treatment ( $P < 0.01$ ), but the evidence quality was downgraded because of a lack of confidence intervals.<sup>51</sup>

*Massage.* A prospective-controlled trial, which included a comparison between acupuncture and massage, found that massage did not produce a significant reduction compared with acupuncture in SCI-related NP intensity.<sup>52</sup> No evidence was found on efficacy of massage on its own.

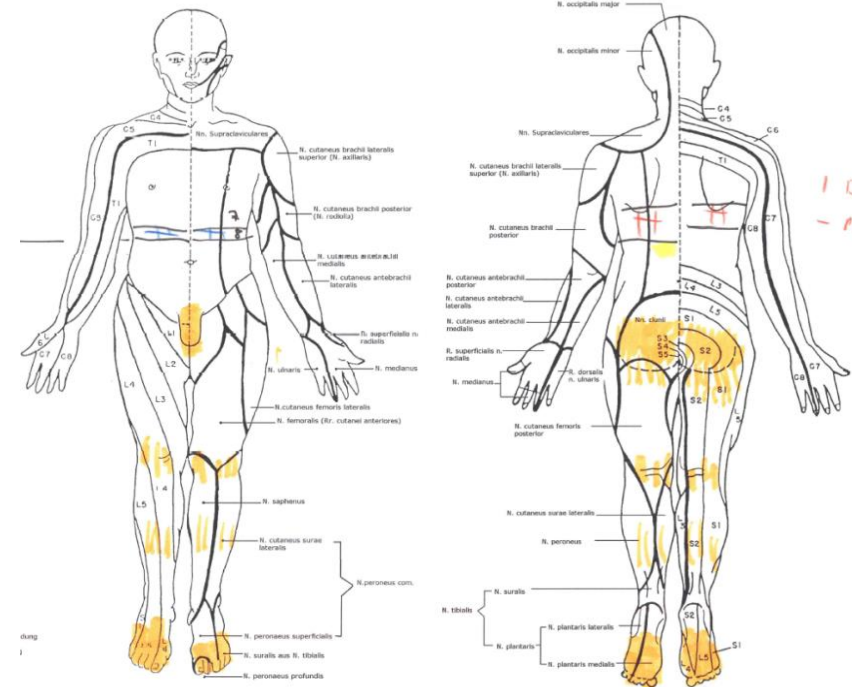
*Osteopathy.* An RCT found a 16% reduction in the perception of SCI-related NP during treatment but not at later time points.<sup>53</sup> No significance was reported for this result, and the evidence quality of this study was downgraded because of a lack of randomization process description, blinding and confidence intervals.

# Own Cases



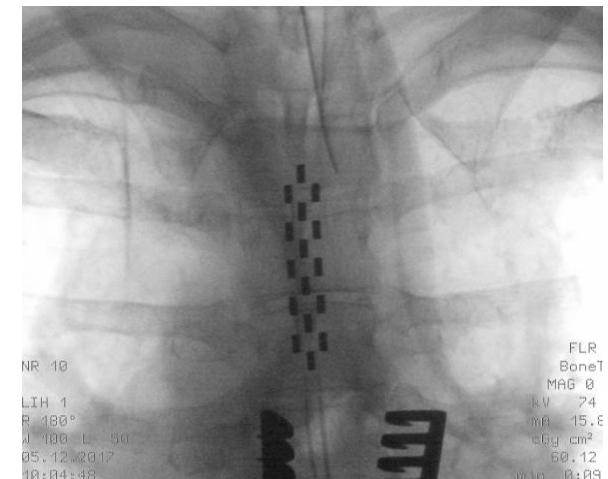
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- 43 yr old patient
- Accident in september 2013
- Fracture of the 7th thoracic vertebra
- Complete paraplegia below Th4
- Below-level SCI pain:
  - burning, stabbing
  - 5-6/10 in the morning
  - up to 10/10 in the late afternoon
  - somehow dependent on physical activity
  - additional pain attacks (any time for a few minutes) up to 10/10



# Own Cases

- Medical treatment: opioids, antineuropathic agents
- Pregabalin 2x200mg
- weight gain of 15kg
- reduction not tolerated
- Psychological evaluation: no contraindication against SCS
- Team decision
- 16-pole surgical lead over the 2nd to the 4th vertebra
- 2 week trial: several parameters
- Pain reduction of 20-30% plus improvement of function (HD stimulation with 1000 Hz and 220 mcs)
- Implantation of the IPG

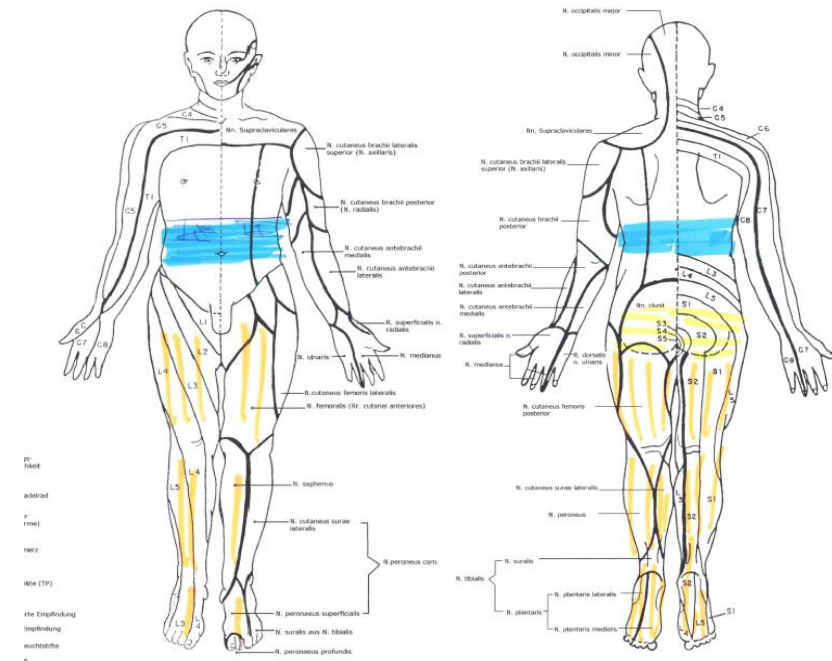


# Own Cases



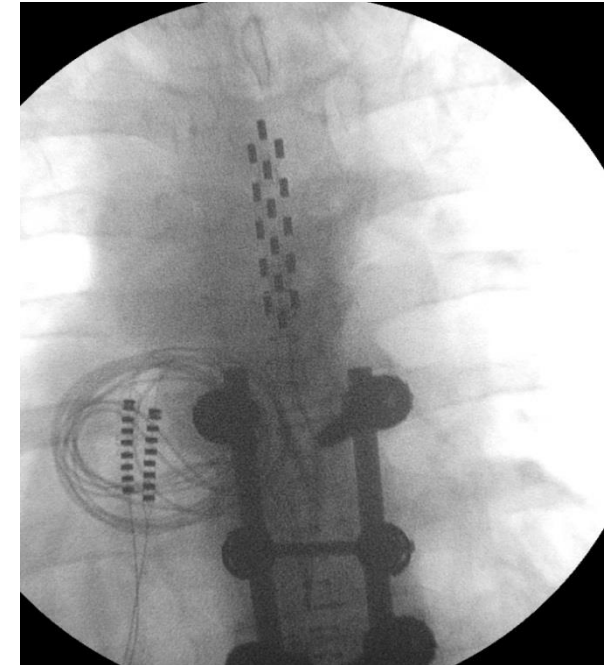
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- 56 yr old patient
- Complete paraplegia below Th6
- Accident in february 2015
- Fracture of the 6th thoracic vertebra
- Several pain locations:
- Below-level SCI pain in the legs (buttocks):
  - burning
  - 5/10 in the morning
  - throughout the day between 6-8/10
- Circular abdominal and dorsal pain
  - somehow burning, but different
  - 5/10 in the morning, between 4-7/10 throughout the day
  - somehow dependent on physical activity



# Own Cases

- Medical treatment: opioids, antineuropathic agents, antidepressants
- most of them to maximum daily dose: no sufficient effect
- Psychological evaluation: no contraindication against SCS
- Team decision
- 16-pole surgical lead over the 3rd to the 5th vertebra
- 2 week trial with several parameters  
>60% pain reduction in the legs and the buttocks, 50% reduction for the circular thoraco-abdominal pain  
(HD stimulation with 1000 Hz and 120 mcs)
- Infection



# Conclusions

- Below-level neuropathic pain in patients with spinal cord injury might be a good indication for spinal cord stimulation
- Even more since we now have systems available that still allow MRI
- At the moment, in our opinion, the lead should be placed just above the lesion
- At the moment, we see high density stimulation to be effective
- SCS therapy should always be embedded in an interdisciplinary therapy

◆ Human Brain Mapping 39:588–598 (2018) ◆

## **New Evidence for Preserved Somatosensory Pathways in Complete Spinal Cord Injury: A fMRI Study**

**Paul J. Wrigley** <sup>1,2,3\*</sup> **Philip J. Siddall**<sup>2,4,5</sup> and **Sylvia M. Gustin**<sup>6,7</sup>

- Are clinically complete paraplegic patients really complete?
- 23 patients with a complete spinal cord injury (AIS A) with or without pain versus 21 people without SCI or pain
- Is there a subclinical preserved somatosensory pathway in clinically complete paraplegia?
- Stimulus: brushing in the insensate area, fMRI
- 11/23 clinically complete patients showed a significant brain activation
- No correlation between this activation and the presence of below-level neuropathic pain





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**Thank you for your attention**