Minimally Invasive Interventional Pain Management

Melissa Tornero-Bold, MD, FASA
Associate Professor, Clinical
Department of Anesthesiology and Pain Medicine
The Ohio State University Wexner Medical Center

MedNet21
Center for Continuing Medical Education

The Ohio State University
Wexner Medical Center

Disclosures

NONE

Navigating Pain Management with Multiple Competing Goals

https://commons.wikimedia.org/wiki/File:Maid_of_the_Mist_VII_approaching_the_Horseshoe_Falls,_West_view_20170418_1.jpg DXR, CC BY-SA 4.0, via Wikimedia Commons

Objectives

- Practical injection and neuromodulation paradigm
- Discuss literature review for common minimally invasive spine procedures
- Identification of appropriate patients for referral for interventional treatment

Interventional Pain Management

- For acute, subacute, and chronic pain
- Complementary to medications
- As an adjunct, or as an alternative, to opioid therapy
- Multimodal comprehensive pain program
- Improve physical and psychosocial function

As part of treatment goal to improve function

Multimodal:

Nonpharmacologic

Medication

Surgery

Early rehabilitation

Barriers:

- Resource allocation
- Insurance noncoverage
- Other (rural, transportation)

Targeted Assessment

- Where is the pain?
- Localized versus generalized?
- Character, quality, timing, duration?
- Medical comorbidities?
- Preexisting medications?
- Surgery / Procedure?
- Risks versus benefits?
- Physician / Patient preference?

https://commons.wikimedia.org/wiki/File:Clipboard_check.svg
Mahua Sarkar, CC0, via Wikimedia Commons

Interventional procedures

- Peripheral nerve blocks
  - ❖ Face and head pain
  - ❖ Trunk
  - ❖ Extremity
- Epidural steroid injections
- Radiofrequency ablation
- Sympathetic blocks
- Chemical neurolysis (Botox)
- Peripheral nerve stimulation
- Spinal cord stimulation
- Intrathecal pain pump

Patient Selection

Chronic pain that continues despite conservative therapy:

- Exercise
- Physical therapy
- Medications

Spine Injections

Epidural Steroid Injections

- Radicular pain

Techniques:

- Interlaminar
- Transforaminal
- Caudal

Radiofrequency Ablation

- Axial spine pain

Epidural injection target = RADICULAR PAIN

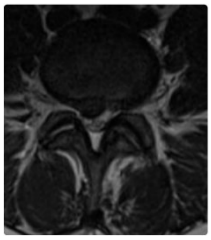
1901

- first documented caudal epidural performed (cocaine), to treat lumbago and sciatica

1952

- first corticosteroid into the lumbar epidural space

Lumbosacral radiculopathy – most common at L4/L5 and L5/S1



Cochrane reviews | Searching for trials | Clinical Answers | About | Help

Cochrane Database of Systematic reviews Review - Intervention

Free access

Epidural corticosteroid injections for lumbosacral radicular pain

Crystian B Oliveira, Christopher G Maher, Manuela L Ferreira, Mark J Hancock, Vinicius Cunha Oliveira, Andrew J McLachlan, Bart W Koes, Paulo H Ferreira, Steven P Cohen, Rafael Zambelli Pinto Authors' declarations of interest

Version published: 09 April 2020 Version history

https://doi.org/10.1002/14651858.CD013577

Conclusion[1]: Epidural steroid injections into the lower spine reduces leg pain and disability at short-term follow-up (moderate evidence)

Facet injection targets

L4-L5 and L5-S1 = AXIAL PAIN

- Synovial joint

Radiofrequency ablation (RFA) heat lesion for pain relief

Chronic spine pain
- Cervical
- Thoracic
- Lumbar

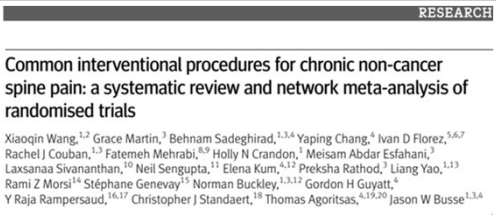
Chronic joint pain before/after joint replacement
- *Knee*
- *Hip*
- *Shoulder*

RFA Candidate

- Receive >80% relief pain relief from diagnostic nerve blocks

Literature Review

- Interventional pain medicine (including neuromodulation) has been criticized from outside the specialty
- Limited by methodological flaws and a lack of context
- It is true that many pivotal trials are industry-funded, given the lack of alternative funding mechanisms & high cost of technology
- Consequences: industry may skew study designs to highlight favorable results, selectively report outcomes, and diminish or selectively exclude less favorable data


RESEARCH

Common interventional procedures for chronic non-cancer spine pain: a systematic review and network meta-analysis of randomised trials

Xiaoqin Wang,[1,2] Grace Martin,[3] Behnam Sadeghirad,[1,3,4] Yaping Chang,[4] Ivan D Florez,[5,6,7] Rachel J Couban,[1,3] Fatemeh Mehrabi,[8,9] Holly N Crandon,[1] Meisam Abdar Esfahani,[3] Laxsanaa Sivananthan,[10] Neil Sengupta,[11] Elena Kum,[4,12] Preksha Rathod,[3] Liang Yao,[1,13] Rami Z Morsi[14] Stéphane Genevay[15] Norman Buckley,[1,3,12] Gordon H Guyatt,[4] Y Raja Rampersaud,[16,17] Christopher J Standaert,[18] Thomas Agoritsas,[4,19,20] Jason W Busse[1,3,4]

- *BMJ. (2025)[2]: Conclusion: This NMA of RCTs provides low to moderate certainty evidence that commonly performed interventional procedures for axial or radicular chronic non-cancer spine pain may provide little to no pain relief, compared to sham procedures*

Limitations of Research

- Continued paucity of high-quality studies for some procedures
- Numerous spine conditions:
  - spinal stenosis
  - post-surgery syndrome
  - discogenic pain
- Comparing procedures (nerve blocks, epidural steroid injections, RFA)
- Poorly reported patient-important outcomes: opioid use/reduction, return to work, sleep
- Procedures “before” versus “bridge to” versus “after” spine surgery


Research

JAMA | Original Investigation

Effect of Spinal Cord Burst Stimulation vs Placebo Stimulation on Disability in Patients With Chronic Radicular Pain After Lumbar Spine Surgery
A Randomized Clinical Trial

Sozaburo Hara, MD; Hege Andresen, RN, MSc; Ole Solheim, MD, PhD; Sven M. Carlsen, MD, PhD; Terje Sundstrøm, MD, PhD; Gregor Lønne, MD, PhD; Vetle V. Lønne, MD; Kristin Taraldsen, PT, PhD; Erling A. Tronvik, MD, PhD; Lise R. Øie, MD, PhD; Agnete M. Gulati, MD, PhD; Lisa M. Sagberg, RN, PhD; Asgeir S. Jakola, MD, PhD; Tore K. Solberg, MD, PhD; Øystein P. Nygaard, MD, PhD; Øyvind O. Salvesen, MSc, PhD; Sasha Gulati, MD, PhD

- *JAMA. (2022)[3]: Conclusions: Patients with spinal cord burst stimulation, compared with placebo stimulation, for spinal cord stimulator resulted in no significant difference in the change from baseline in self-reported back pain–related disability*

Response in JAMA from expert societies[4]:


Comment & Response

Spinal Cord Burst Stimulation vs Placebo Stimulation for Patients With Chronic Radicular Pain After Lumbar Spine Surgery

Corey W. Hunter, MD[1]; Joshua Rosenow, MD[2]; Marc Russo, MBBS, DA[3]

> Author Affiliations | Article Information

- American Association of Neurological Surgeons
- American Academy of Pain Medicine
- American Society of Pain and Neuroscience
- Congress of Neurological Surgeons
- International Neuromodulation Society
- North American Neuromodulation Society

Serious concerns about RCT[4]:

- Protocol used previous unpublished set amplitude therapy = therefore unproven/untested type of "burst" spinal cord stimulation using unconfirmed parameters
- Suggests this trial compared one placebo vs another placebo
- Patients remained at a set stimulation amplitude without optimizing therapy for each individual patient = deviation from standard practice
- Unclear whether "placebo" stimulation was "no stimulation" versus "lower" amplitude of stimulation
- Nonoptimization of SCS therapy group and withholding patients to control stimulation = not personalized "standard of care"

The Experts Evidence-Based Guidelines:

Epidurals

Facets

American Society of Interventional Pain Physicians (ASIPP)

- Revised Guidelines for Epidurals (2021)[5]; *original 2013*
- Guidelines for Facet Joint Interventions (2020)[6]

The Experts Evidence-Based Guidelines:

Intrathecal "pain pump"

International Neuromodulation Society (INS)

- The Polyanalgesic Consensus Conference (PACC)®: Intrathecal Drug Delivery Guidance on Safety and Therapy Optimization When Treating Chronic Noncancer Pain (2024)[7]
- PACC® guidelines: *previous 2017, 2012*

The Experts Evidence-Based Guidelines:

Spinal Cord Stimulation

International Neuromodulation Society (INS)

- The Neurostimulation Appropriateness Consensus Committee (NACC)®: Recommendations for the Mitigation of Complications of Neurostimulation (2024)[8]
- Infection prevention, surgical complications like lead migration, management
- NACC® guidelines: *previous 2017*

Common Pain Targets

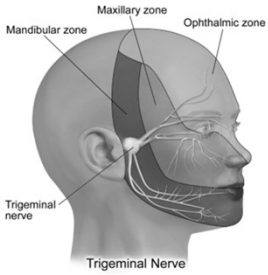
https://commons.wikimedia.org/wiki/File:Exam_room_in_a_doctor%27s_office.jpg
Harrison Keely, CC BY 4.0, via Wikimedia Commons

Head Pain Injections

Botox Chemical Neurolysis for Migraine Prophylaxis

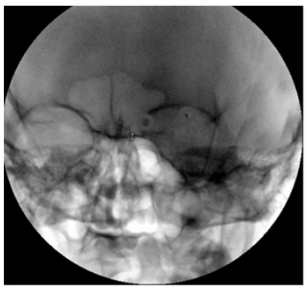
https://pixabay.com/illustrations/ai-generated-cosmetic-injection-9087001/

Trigeminal Neuralgia



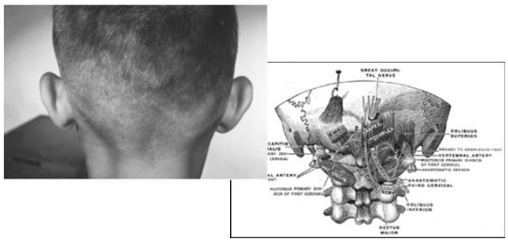
BruceBlaus, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons

Trigeminal Neuralgia



- 59y/o female with trigeminal neuralgia following migraine surgery
- Left supraorbital block
- Left supratrochlear block
- 100% relief

Occipital Neuralgia

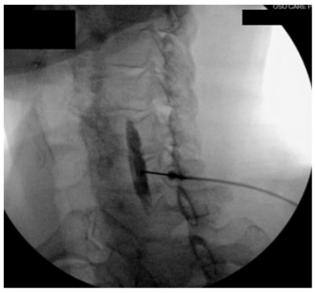


https://phil.cdc.gov/Details.aspx?pid=15895
Henry Vandyke Carter, Public domain, via Wikimedia Commons

Stellate Ganglion Block

Old dog,
New tricks

- **CPRS**
- **COVID, PTSD[9]**



Joint Pain

Radio-Frequency (RFA) heat lesion for Pain Relief

Chronic joint pain before/after joint replacement

- Knee
- Hip
- Shoulder

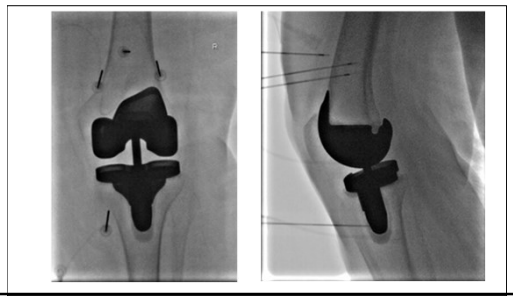
Chronic spine pain

- *Cervical*
- *Thoracic*
- *Lumbar*

RFA for Pain following total knee replacement

- 68y/o female s/p right total knee arthroplasty with worse pain following joint replacement
- Knee radiofrequency performed with 80% relief
- s/p peripheral nerve stimulator of right common peroneal nerve 80% relief

RFA for Pain following total knee replacement



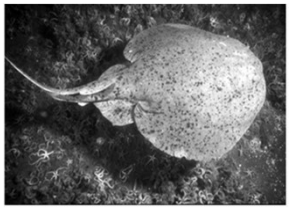
Nerve Stimulation for Pain Control

Spinal Cord Stimulation

AND

Peripheral Nerve Stimulation

First century gout pain was relieved by standing on an electrical fish



Ancient Rome physician Scribonius Largus

electrical Torpedo fish at the seashore

Kathy Dewet-Oleson, NOAA National Marine Sanctuaries, Public domain, via Wikimedia Commons

Electrical Stimulation for Pain Control*

- In the 16th through the 18th century various electrostatic devices were used for headache and other pains[10]
- Benjamin Franklin was a proponent of this method for pain relief

19th century device called the Electreat

- Pain control, improve health and cancer cures
- Only the Electreat survived into the 20th century, had limited control of the stimulus
- FDA reports misbranding of device; that its treatment claims are false, 1947

English: National Park Service Picture – Courtesy of Hot Springs National Park Archives, Public domain, via Wikimedia Commons

TENS (Transcutaneous Electrical Nerve Stimulator)

- Electric current produced by device to stimulates the nerves for therapeutic purposes

Yeza, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons

(Interventional = Invasive) Peripheral Nerve Stimulation

- Neuropathy = nerve pain along a named nerve distribution
- Therapeutic Targets
  - Pain before or after joint replacement
    - shoulder, hip, knee, ankle, elbow…
  - Axial spine pain
  - Post-amputation pain
  - Post-stroke pain
  - Post-traumatic pain
  - Complex regional pain syndrome (CRPS)

Reversible PNS for Acute and Chronic Pain

- FDA cleared percutaneous peripheral nerve stimulation system designed for use in the periphery
- Used in acute post-surgical pain as well as chronic intractable pain
- Implanted for 60 days, zero cases of infection[11,12]

[1]Chae, J., David, T.Y., Walker, M.E., Kirsteins, A., Elovic, E.P., Flanagan, S.R., & Fang, Z.P. (2005) Intramuscular electrical stimulation for hemiplegic shoulder pain: a 12-month follow-up of a multiple-center, randomized clinical trial. American journal of physical medicine & rehabilitation, 84(11), 832-842.

[2]Gilmore C.A., Ilfeld B.M., Rosenow J.M., Li S., Desai M.J., Hunter C.W., Nader A., Mak J., Rauck R.L., Kapural L., Crosby N.D., Boggs J.W. (2018). Percutaneous peripheral nerve stimulation (PNS) for the treatment of chronic neuropathic post-amputation pain: Initial results from a multicenter, randomized, placebo-controlled study. Napa Pain Conference.

Implantable PNS (Permanent)

- Primary Safety Endpoint defined by the FDA as a 30% decrease in pain[13]
- Thin Lead is Percutaneously Implanted Next to Target Peripheral Nerve
- Minimally Invasive, long-term treatment option
- External Battery sends stimulation to the lead
- MRI Conditional/Limitations

Contraindications for PNS

- Need for MRI
- Pacemaker/defibrillator
- DBS
- Allergy to tape or adhesive

First Spinal Cord Stimulator - 1967

- Inventor Clyde Norman Shealy, M.D. , Ph.D is a Neurosurgeon and a pain pioneer[14]

Spinal Cord Stimulation

- Minimally invasive surgery
- MRI compatible up to 1.5 Tesla
- Stimulator leads can be placed in many different regions
  - Most commonly in the epidural space to modulate the dorsal column of the spinal cord
  - Peripheral nerves
  - Facial nerves

Gate Control Theory

- Hypothesized SCS stimulation of the dorsal columns inhibits the activity of the dorsal horn neurons
- Sends electrical activity to neurons in the spinal cord, thalamus and somatosensory cortices per pain matrix
- Modulates pain by decreasing sympathetic outflow and tone, activates descending inhibitory pathways
- Modulates many different chemicals that work on pain
  - Increases GABA (helps to inhibit pain signals in the spinal cord)
  - Increases glycine
  - Decreases substance P

SCS Indications

- Failed back surgery * most prevalent
- Post-laminectomy syndrome
- Lumbar radiculopathy
- Neuropathic pain
- CRPS type 1 and 2
- Plexopathy
- Peripheral neuropathy
- Phantom limb pain
- Post-herpetic neuralgia
- Refractory angina

Literature Review

- SCS can be preferred to repeat surgery[15]
- SCS was less expensive and more effective than reoperation in selected failed back–surgery syndrome patients, and should be the initial therapy of choice
- SCS is most cost–effective when patients forego repeat operation
- SCS compared to conventional medication management showed almost 50% with primary outcome of 50% or more leg pain relief *compared to 9% of medication patients*[16]

Intrathecal Pain Pump for Intractable Pain

- A medication reservoir is connected to intrathecal catheter to deliver medications directly into the intrathecal space
- Bypass the blood brain barrier

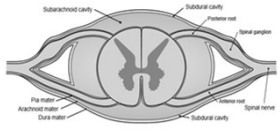


Photo By Mysid - Made by Mysid Inkscape, based on plate 770 from Gray's Anatomy (1918, public domain)., Public Domain, https://commons.wikimedia.org/w/index.php?curid=10496507

Intrathecal Therapy for Severe Pain

- Pain is present in 20-50% of patients with cancer, and in up to 80% of patients with advanced cancer*
- Oral, sublingual, buccal, transdermal opioids are ineffective at reasonable doses or cause unacceptable side effects

https://www.cancer.gov/about-cancer/treatment/side-effects/pain/pain-hp-pdq

Indications for Intrathecal Therapy

- Cancer pain and pain of spinal origin; majority of pumps placed in the United States for failed back surgery syndrome
- Baclofen for significant spinal cord injury or significant spasticity with success
- FDA approved drugs: ziconotide, baclofen, and morphine

Overall Contraindications

Does not want any procedure	Unable to take off blood thinners	Platelet count <75-100
Skin issues, radiation in area procedure, infection	Neutropenic, coagulopathic	Local tissue destruction, organomegaly

Neurological Red Flags - Spinal Cord Compression

- New bowel/bladder dysfunction
- Acute loss of motor function in the limbs
- Hyperreflexia
- Imaging, ideally MRI if possible
  - If previous spinal hardware consider MRI with contrast

Bidgee, CC BY 3.0 <https://creativecommons.org/licenses/by/3.0>, via Wikimedia Commons

Goals of Care Improve Function

MORE (& treat pain less)

Pain management as bridge for purpose-driven life in the foreground…pain in background

https://commons.wikimedia.org/wiki/File:JoshuaTreeCA_Rainbow_20170909.jpg
Niranjan Arminius, CC BY-SA 4.0, via Wikimedia Commons

"Do the best you can until you know better.
Then when you know better, do better."
- *Maya Angelou*

https://commons.wikimedia.org/wiki/File:V%C3%A4imela_Alaj%C3%A4rv_2012_08.jpg
Vaido Otsar, CC BY-SA 3.0, via Wikimedia Commons

References

1. *Oliveira CB, Maher CG, Ferreira ML, Hancock MJ, Oliveira VC, McLachlan AJ, Koes BW, Ferreira PH, Cohen SP, Pinto RZ. Epidural corticosteroid injections for lumbosacral radicular pain. Cochrane Database of Systematic Reviews 2020, Issue 4. Art. No.: CD013577. DOI: 10.1002/14651858.CD013577. Accessed 02 February 2026.*

2. *Wang X, Martin G, Sadeghirad B, Chang Y, Florez ID, Couban RJ, Mehrabi F, Crandon HN, Esfahani MA, Sivananthan L, Sengupta N, Kum E, Rathod P, Yao L, Morsi RZ, Genevay S, Buckley N, Guyatt GH, Rampersaud YR, Standaert CJ, Agoritsas T, Busse JW. Common interventional procedures for chronic non-cancer spine pain: a systematic review and network meta-analysis of randomised trials. BMJ. 2025 Feb 19;388:e079971. doi: 10.1136/bmj-2024-079971. PMID: 39971346.*

3. *Hara S, Andresen H, Solheim O, et al. Effect of Spinal Cord Burst Stimulation vs Placebo Stimulation on Disability in Patients With Chronic Radicular Pain After Lumbar Spine Surgery: A Randomized Clinical Trial. JAMA. 2022;328(15):1506–1514. doi:10.1001/jama.2022.18231*

4. *Hunter CW, Rosenow J, Russo M. Spinal Cord Burst Stimulation vs Placebo Stimulation for Patients With Chronic Radicular Pain After Lumbar Spine Surgery. JAMA. 2023;329(10):847–848. doi:10.1001/jama.2022.24751*

References

5. Manchikanti L, Knezevic NN, Navani A, Christo PJ, Limerick G, Calodney AK, Grider J, Harned ME, Cintron L, Gharibo CG, Shah S, Nampiaparampil DE, Candido KD, Soin A, Kaye AD, Kosanovic R, Magee TR, Beall DP, Atluri S, Gupta M, Helm Ii S, Wargo BW, Diwan S, Aydin SM, Boswell MV, Haney BW, Albers SL, Latchaw R, Abd-Elsayed A, Conn A, Hansen H, Simopoulos TT, Swicegood JR, Bryce DA, Singh V, Abdi S, Bakshi S, Buenaventura RM, Cabaret JA, Jameson J, Jha S, Kaye AM, Pasupuleti R, Rajput K, Sanapati MR, Sehgal N, Trescot AM, Racz GB, Gupta S, Sharma ML, Grami V, Parr AT, Knezevic E, Datta S, Patel KG, Tracy DH, Cordner HJ, Snook LT, Benyamin RM, Hirsch JA. Epidural Interventions in the Management of Chronic Spinal Pain: American Society of Interventional Pain Physicians (ASIPP) Comprehensive Evidence-Based Guidelines. Pain Physician. 2021 Jan;24(S1):S27-S208. PMID: 33492918.

6. Manchikanti L, Kaye AD, Soin A, Albers SL, Beall D, Latchaw R, Sanapati MR, Shah S, Atluri S, Abd-Elsayed A, Abdi S, Aydin S, Bakshi S, Boswell MV, Buenaventura R, Cabaret J, Calodney AK, Candido KD, Christo PJ, Cintron L, Diwan S, Gharibo C, Grider J, Gupta M, Haney B, Harned ME, Helm Ii S, Jameson J, Jha S, Kaye AM, Knezevic NN, Kosanovic R, Manchikanti MV, Navani A, Racz G, Pampati V, Pasupuleti R, Philip C, Rajput K, Sehgal N, Sudarshan G, Vanaparthy R, Wargo BW, Hirsch JA. Comprehensive Evidence-Based Guidelines for Facet Joint Interventions in the Management of Chronic Spinal Pain: American Society of Interventional Pain Physicians (ASIPP) Guidelines Facet Joint Interventions 2020 Guidelines. Pain Physician. 2020 May;23(3S):S1-S127. PMID: 32503359.

References

7. Deer TR, Hayek SM, Grider JS, Hagedorn JM, McDowell GC 2nd, Kim P, Dupoiron D, Goel V, Duarte R, Pilitsis JG, Leong MS, De Andrés J, Perruchoud C, Sukumaran H, Abd-Elsayed A, Saulino M, Patin D, Poree LR, Strand N, Gritsenko K, Osborn JA, Dones I, Bux A, Shah JM, Lindsey BL, Shaw E, Yaksh TL, Levy RM. The Polyanalgesic Consensus Conference (PACC)®: Intrathecal Drug Delivery Guidance on Safety and Therapy Optimization When Treating Chronic Noncancer Pain. Neuromodulation. 2024 Oct;27(7):1107-1139. doi: 10.1016/j.neurom.2024.03.003. Epub 2024 May 16. PMID: 38752946.

8. Deer TR, Russo MA, Sayed D, Pope JE, Grider JS, Hagedorn JM, Falowski SM, Al-Kaisy A, Slavin KV, Li S, Poree LR, Eldabe S, Meier K, Lamer TJ, Pilitsis JG, De Andrés J, Perruchoud C, Carayannopoulos AG, Moeschler SM, Hadanny A, Lee E, Varshney VP, Desai MJ, Pahapill P, Osborn J, Bojanic S, Antony A, Piedimonte F, Hayek SM, Levy RM. The Neurostimulation Appropriateness Consensus Committee (NACC)®: Recommendations for the Mitigation of Complications of Neurostimulation. Neuromodulation. 2024 Aug;27(6):977-1007. doi: 10.1016/j.neurom.2024.04.004. Epub 2024 Jun 13. PMID: 38878054.

9. Rae Olmsted KL, Bartoszek M, Mulvaney S, McLean B, Turabi A, Young R, Kim E, Vandermaas-Peeler R, Morgan JK, Constantinescu O, Kane S, Nguyen C, Hirsch S, Munoz B, Wallace D, Croxford J, Lynch JH, White R, Walters BB. Effect of Stellate Ganglion Block Treatment on Posttraumatic Stress Disorder Symptoms: A Randomized Clinical Trial. JAMA Psychiatry. 2020 Feb 1;77(2):130-138. doi: 10.1001/jamapsychiatry.2019.3474. Erratum in: JAMA Psychiatry. 2020 Feb 1;77(2):218. doi: 10.1001/jamapsychiatry.2019.4511. Erratum in: JAMA Psychiatry. 2020 Sep 1;77(9):982. doi: 10.1001/jamapsychiatry.2020.1829. PMID: 31693083; PMCID: PMC6865253.

References

10. Kane K, Taub A. A history of local electrical analgesia. Pain. 1975 Jun;1(2):125-138. doi: 10.1016/0304-3959(75)90097-4. PMID: 800638.

11. Chae J, Yu DT, Walker ME, Kirsteins A, Elovic EP, Flanagan SR, Harvey RL, Zorowitz RD, Frost FS, Grill JH, Fang ZP. Intramuscular electrical stimulation for hemiplegic shoulder pain: a 12-month follow-up of a multiple-center, randomized clinical trial. Am J Phys Med Rehabil. 2005 Nov;84(11):832-42. doi: 10.1097/01.phm.0000184154.01880.72. PMID: 16244520.

12. Gilmore C, Ilfeld B, Rosenow J, Li S, Desai M, Hunter C, Rauck R, Kapural L, Nader A, Mak J, Cohen S, Crosby N, Boggs J. Percutaneous peripheral nerve stimulation for the treatment of chronic neuropathic postamputation pain: a multicenter, randomized, placebo-controlled trial. Reg Anesth Pain Med. 2019 Jun;44(6):637-645. doi: 10.1136/rapm-2018-100109. Epub 2019 Apr 5. PMID: 30954936.

13. Deer T, Pope J, Benyamin R, Vallejo R, Friedman A, Caraway D, Staats P, Grigsby E, Porter McRoberts W, McJunkin T, Shubin R, Vahedifar P, Tavanaiepour D, Levy R, Kapural L, Mekhail N. Prospective, Multicenter, Randomized, Double-Blinded, Partial Crossover Study to Assess the Safety and Efficacy of the Novel Neuromodulation System in the Treatment of Patients With Chronic Pain of Peripheral Nerve Origin. Neuromodulation. 2016 Jan;19(1):91-100. doi: 10.1111/ner.12381. PMID: 26799373.

References

14. Shealy CN, Mortimer JT, Reswick JB. Electrical inhibition of pain by stimulation of the dorsal columns: preliminary clinical report. Anesth Analg. 1967 Jul-Aug;46(4):489-91. PMID: 4952225.

15. North RB, Kidd D, Shipley J, Taylor RS. Spinal cord stimulation versus reoperation for failed back surgery syndrome: a cost effectiveness and cost utility analysis based on a randomized, controlled trial. Neurosurgery. 2007 Aug;61(2):361-8; discussion 368-9. doi: 10.1227/01.NEU.0000255522.42579.EA. Erratum in: Neurosurgery. 2009 Apr;64(4):601. PMID: 17762749.

16. Kumar K, Taylor RS, Jacques L, Eldabe S, Meglio M, Molet J, Thomson S, O'Callaghan J, Eisenberg E, Milbouw G, Buchser E, Fortini G, Richardson J, North RB. Spinal cord stimulation versus conventional medical management for neuropathic pain: a multicentre randomised controlled trial in patients with failed back surgery syndrome. Pain. 2007 Nov;132(1-2):179-88. doi: 10.1016/j.pain.2007.07.028. Epub 2007 Sep 12. PMID: 17845835.