

STIMULACIJA KIČMENE MOŽDINE U LIJEČENJU HRONIČNE BOLI

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Project number: 585927-EPP-1-2017-1-RS-EPPKA2-CBHE-JP (2017 – 3109 / 001 – 001)

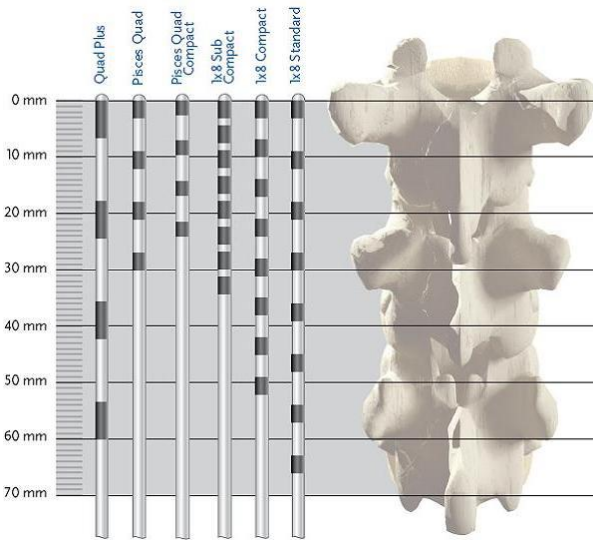
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Stimulacija kičmene moždine (SCS - spine cord stimulation) je neuromodulaciona tehnika koja redukuje bol bolelektričnom stimulacijom dorzalnih stubova kičmene moždine.

Primjena se preporučuje kada se konvencionalno, multidisciplinarno liječenje neuropatskog ili mješovitog bola pokaže neuspješnim.

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Melzack R, Wall PD. Pain mechanisms: a new theory. *Science (New York, N.Y.)*. **1965**;150:971-979.

Shealy CN, Mortimer JT, Reswick JB. Electrical inhibition of pain by stimulation of the dorsal columns: preliminary clinical report. *Anesth Analg*. **1967**;46:489-491.

-Godišnje se ugradi 50000 neurostimulatora kičmene moždine

-Rast je podstaknut povećanom prevalencom neuropatskog bola,

van Hecke O, Austin SK, Khan RA, Smith BH, Torrance N. Neuropathic pain in the general population: a systematic review of epidemiological studies. *Pain*. **2014**;155:654-662.

-Porastom pacijenata sa sindromom FBSS (failed back surgery syndrome)

Thomson S. Failed back surgery syndrome - definition, epidemiology and demographics. *Br J Pain*. **2013**;7:56-59.

i pokušaja da se koriste druge strategije umjesto hronične opioidne terapije

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INDIKACIJE ZA UGRADNJU SCS SISTEMA

Failed Back Surgery Syndrome (FBSS)

□ SCS je superiorniji u odnosu na konzervativni medicinski tretman na 6. 12. i 24. mjeseca u redukciji bola u nozi (>50%), poboljšanju funkcije i kvaliteta života

Kumar K, Taylor RS, Jacques L, Eldabe S, Meglio M, Molet J, et al. 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. *Neurosurgery*. **2008**;63:762-770; discussion 770

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□ Signifikantno je veći broj pacijenata sa sistemom SCS i optimalnim medicinskim tretmanom, koji imaju smanjenje bola za >50% u slabinskom segmentu na 6 mjesecu od zahvata u odnosu na pacijente kod kojih je primjenjen samo optimalni medicinski tretman.

Rigoard P, Desai MJ, North RB, Taylor RS, Annemans L, Greening C, et al. Spinal cord stimulation for predominant low back pain in failed back surgery syndrome: study protocol for an international multicenter randomized controlled trial (PROMISE study). *Trials*. **2013**;14:376

□ SCS je efikasna za liječenje neuropatskog bola kod FBSS. Najnovija naučna i tehnička unapređenja SCS sistema, novi oblici talasa i paradigmi doveli su do poboljšanja ishoda tretmana, posebno dugoročnog smanjenja bola i povećanja funkcionalne sposobnosti. Pažljiva preoperativna selekcija je i daje najvažnija za dugoročan uspjeh SCS terapije.

Kapural R, Peterson E, Provenzano DA, Staats P. Clinical evidence for spinal cord stimulation for Failed Back Surgery Syndrome (FBSS): Systematic review. *SPINE*. March **2017**.

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□ SCS je dokazano najefikasnija forma polu-invazivnih tretmana kod pacijenata sa predominantnom neuropatskom boli u donjem ekstremitetu. Signifikantno je veći broj pacijenata sa sistemom SCS ugrađenim nakon operativnih zahvata na slabinskom segmentu kičmenog stuba imao smanjenje bola za 50% i više. u odnosu na pacijente podvrgnute reoperativnih zahvatima.

Daniell JR, Osti OL. Failed Back Surgery Syndrome: A Review Article. *Asian Spine J* **2018**;12(2):372-379

□ SCS u poređenju sa konvencionalnim medikamentoznim liječenjem pokazuje umjereno jake dokaze veće efikasnosti u odnosu na redukciju bola, funkcionalni ishod i ukupno zadovoljstvo pacijenta.

Mekhail N, Visnjevac O, Azer G, Mehanny DS, Agrawal P, Foorsov V. Spinal Cord Stimulation 50 Years Later Clinical Outcome of Spinal Cord Stimulation Based on Randomized Clinical Trials –A Systematic Review. *Reg Anesth Pain Med.* May **2018**; 43(4): 00-00.

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Kompleksni regionalni bolni sindrom (CRPS)

□ SCS je povoljan i efektivan modalitet u CRPS sa visokim nivoom dokaza (1B+) koji podržavaju njegovu ulogu u smanjenu bola, poboljšanju kvaliteta života.

Visnjevac O, Costandi S, Patel BA, Azer G, Agarwal P, Bolash R, Mekhail NA. A Comprehensive Outcome-Specific Review of the Use of Spinal Cord Stimulation for Complex Regional Pain Syndrome. *Pain Pract.* **2017** Apr;17(4):533-545

□ 95% pacijenata je bilo zadovoljno svojim tretmanom SCS nakon pet godina od implantacije sistema. SCS ima pozitivan efekat u smislu smanjenja bola (1B+), kvaliteta života (1B+) i ukupnog zadovoljstva (2C+). SCS je efikasniji ukoliko je sistem implantiran u prvoj godini od početka bolesti i u pacijenata mlađih od 40 godina.

Urits J, Shen AH, James MR, Viswanath O, Kaye AD. Complex Regionaln Pain Syndrome, Current Concept and Treatment Options. *Current Pain and Headache Reports.* **2018**; 22:10

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□ Implantacijom SCS dobijeno je signifikantno smanjenje bola i poboljšanje funkcionalnosti u svim slučajevima pacijenata sa CRPS tip I.

Risson EG, Serpa AP, Berger JJ, Koerbel RFH, Koerbel A. Spinal Cord Stimulation In The Treatment Of Complex Regional Pain Syndrome Type 1: Is Trial Truly Required? Clin Neurol Neurosurg. **2018** Aug;171:156-16



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- SCS daje superiorne dokaze u tretmanu **refraktorne angine pektoris (RAP)** u pogledu smanjenja bola, poboljšanju funkcionalnog statusa u poređenju sa medikamentoznom terapijom.

- SCS pokazuje umjereno jake dokaze u poboljšanju funkcionalnog statusa i smanjenja upotrebe lijekova kod pacijenata sa **kritičnom ishemijom ekstremiteta (CLI)**.

Mekhail N, Visnjevac O, Azer G, Mehanny DS, Agrawal P, Foorsov V. Spinal Cord Stimulation 50 Years Later Clinical Outcome of Spinal Cord Stimulation Based on Randomized Clinical Trials –A Systematic Review. Reg Anesth Pain Med. May 2018; 43(4): 00-00.

Bolna dijabetička polineuropatija (PDPN)

□ SCS nudi nivo 1A+ dokaza za efikasnost u redukciji bola i poboljšanju kvaliteta života u poređenju sa medikamentoznom terapijom u tretmanu bolne dijabetičke polineuropatije.

Mekhail N, Visnjevac O, Azer G, Mehanny DS, Agrawal P, Foorsov V. Spinal Cord Stimulation 50 Years Later Clinical Outcome of Spinal Cord Stimulation Based on Randomized Clinical Trials –A Systematic Review. Reg Anesth Pain Med. May 2018; 43(4): 00-00.

□ SCS se pokazala uspješnom u redukciji hroničnog bola u donjim ekstremitetima kod pacijenata sa PDPN nakon petogodišnjeg praćenja. 80% pacijenata još koriste svoj SCS sistem nakon 5 godina.

van Beek M, Geurts JW, Slangen R, Schaper NC, Faber CG, Joosten EA, et al. Severity of Neuropathy Is Associated With Long-Term Spinal Cord Stimulation Outcome in Painful Diabetic Peripheral Neuropathy: Five-Year Follow-up of a Prospective Two-Center Clinical Trial. Diabetes Care 2018 Jan;41(1):32-38

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□ Prvi izvještaj u slučaju ugradnje hirurških elektroda SCS sistema kod CRPS na nivou C1-C2 sa vrhom do C4 sa bilateralnim pokrićem gornjih dermatoma za gornje ekstremiteta ukazuje na signifikantno smanjenje bola i kompletno odsustvo spinalnog mioklonusa.

Bosea R, Banerjee AD. Spinal cord stimulation for complex regional pain syndrome type I with spinal myoclonus – a case report and review of literature. *Br J Neurosurg.* **2019** Jan 12:1-3.

□ SCS je efektivna terapija kod C-FBSS u smislu poboljšanja kvaliteta života pacijenta, ukupnog zadovoljstva pacijenta i smanjenja bola (procenat smanjenja bola je bio 65,2%, 62,4% i 71,9% mjerena trećeg, šestog i dvanaestog mjeseca od implantacije). Uspješna primjena SCS kao terapije je u velikoj mjeri zasnovana na principu dobre selekcije pacijenta, izbora implantacione tehnike i stimulacionih parametara.

Hunter CW, Carlson J, Yang A, Deer T. Spinal Cord Stimulation for the Treatment of Failed Neck Surgery Syndrome: Outcome of a Prospective Case Series. *Neuromodulation* **2018** Jul;21(5):495-503.

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Stimulacija kičmene moždine je:

- JEDNOSTAVNA PROCEDURA
- NISKO RIZIKA
- SA MINORNIM KOMPLIKACIJAMA
- JEFTINA
- KOMPLETNO REVERZIBILNA

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Mechanisms of spinal cord stimulation for the treatment of pain: Still in the dark after 50 years

Jensen, M. P., & Brownstone, R. M. *Eur J Pain.* **2019**; 23:652–659.

SCS indukuje oslobađanje serotonina i norepinefrina u dorzalnim rogovima preko descedentnih puteva iz moždanog stabla.

Von Hehn, C. A., Baron, R., & Woolf, C. J. *Deconstructing the Neuropathic Pain Phenotype to Reveal Neural Mechanisms.* *Neuron.* **2012**, 73(4), 638–652

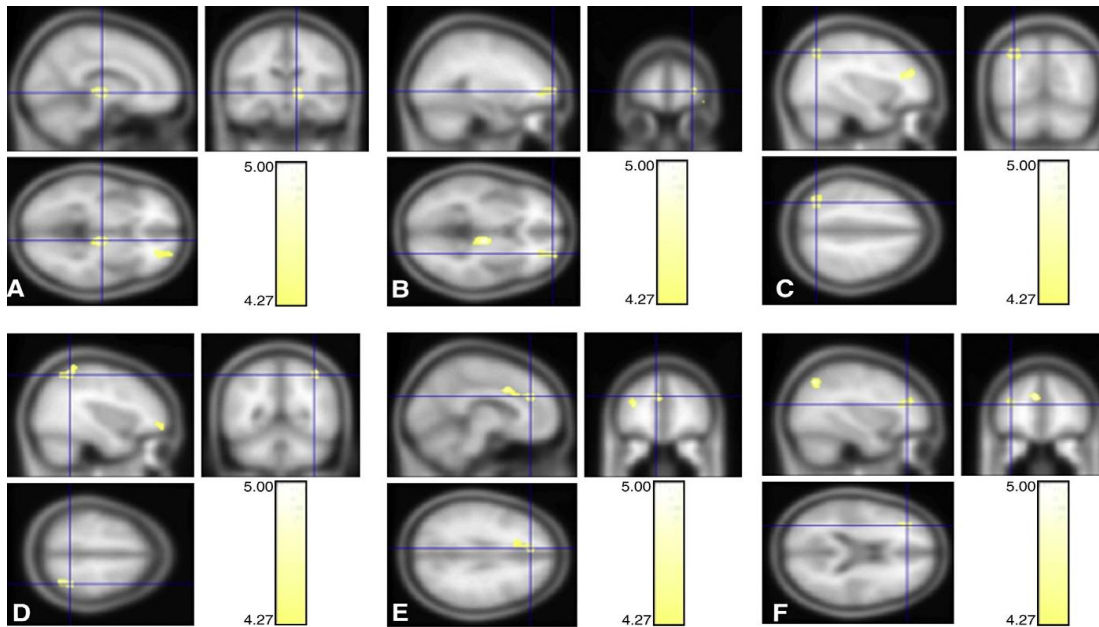
Električna stimulacija dorzalnih rogova utiče na aktivnost neurona u talamusu i somatosenzornom korteksu.

Barchini J, Tchachaghalian S, Shamaa P, Jabbur SJ, Meyerson BA, Song Z, Linderoth B, Saade NE. Spinal segmental and supraspinal mechanisms underlying the pain-relieving effects of spinal cor stimulation and experimental study in a rat model of neuropathy. *Neuroscience.* 2012; 215: 196-208.

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PET dokazuju da SCS povećava krvni protok u talamusu, parijetalnoj asocijativnoj bilateralnoj arei, prednjem cingularnom korteksu i prefrontalnom korteksu – ukazuje da reguliše prag bola u talamusu i parijetlnoj asocijativnoj arei dok su preostala dva segmenta uključena u emocionalne aspekte bola.



Statistical parametric maps (Z maps) of intensity in normalized images. Comparison of rCBF before and after SCS shows that rCBF is increased after SCS in the right thalamus (A), right orbitofrontal cortex (BA11) (B), left inferior parietal lobule (C), right superior parietal lobule (D), left anterior cingulate cortex (E), and left dorsolateral prefrontal cortex (F).

Haruhiko Kishima, Youichi Saitoh, Satoru Oshino, Koichi Hosomi, Mohamed Ali, Tomoyuki Maruo, Masayuki Hirata, Tetsu Goto, Takufumi Yanagisawa, Masahiko Sumitani, Yasuhiro Osaki, Jun Hatazawa, Toshiki Yoshimine. Modulation of neuronal activity after spinal cord stimulation for neuropathic pain; H2150 PET study. *Neuroimage*. **2010**; 49(3): 2564-2569.

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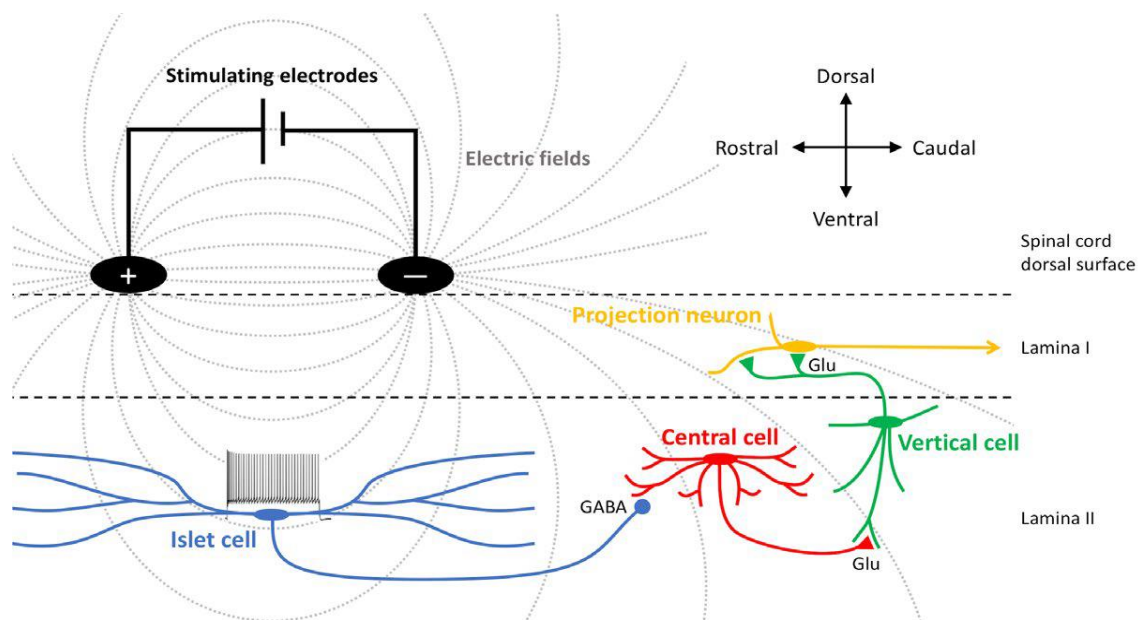
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fMRI ukazuje da SCS redukuje afektivne komponente bola modulirajući aktivnost somatosenzornog korteksa smanjujući njegovu vezu sa asocijativnim limbičkim areama.

Qin, C., Yang, X., Wu, M., Farber, J. P., Linderoth, B., & Foreman, R. D. (2009). Modulation of neuronal activity in dorsal column nuclei by upper cervical spinal cord stimulation in rats. Neuroscience, 164(2), 770–776

Primjenom SCS na modelu glodara ukazuje na redukciju i skraćenje dugoročne potencijacije i modulacije hiperekscitabilnosti WDR neurona u dorzalnim rogovima, vjerovatno povezano sa redukcijom u ekstracel. konc. GABA-e.

Wallin J, Fiskå A, Tjölsen A, Linderoth B, Hole K. Spinal cord stimulation inhibits longterm potentiation in spinal WDR neurons. Brain Res. 2003;973:39–43



Schematic illustrating proposed mechanism of action of spinal cord stimulation for pain. Surface stimulation (black electrodes) produces electric fields (grey lines) that span dorsal horn islet cells (blue) leading to activation of their dendrites, depolarization, and thus trains of action potentials. Islet cells in turn would inhibit transmission between excitatory interneurons (shown as central cells, red and vertical cells, green), which would result in reduced activity of projection neurons (shown as lamina I projection neurons, yellow). (cf. Lu and Perl, 2005; Todd, 2017).

Jensen, M. P., & Brownstone, R. M. **Mechanisms of spinal cord stimulation for the treatment of pain: Still in the dark after 50 years** *Eur J Pain.* **2019**; 23:652–659.

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U toku primjene SCS uočeno je da dolazi do povećanog krvnog protoka u ekstremitetima u dermatomima koji odgovaraju segmentnom nivou implantiranih elektroda. Ova zapažanja vode do eventualnog uspjeha SCS u tretmanu ishemičnih stanja u perifernim vaskularnim oboljenjima.

Vallejo R, Bradley K, Kapural L. Spinal Cord Stimulation in Chronic Pain: Mode of Action. *Spine*. **2017**; S53-S60.

Uloga glijalnih ćelija (astrociti) u nastanu neuropatske boli-modulišu aktivnost neurotransmitera i koncentraciju citokina. U stanju su da razaznaju obrazac stimulacije.

Milligan ED, Watkins LR. Pathological and protective roles of glia in chronic pain. *Nat Rev Neurosci*. **2009**;10(1):23-36.

Todd KJ, Darabid H, Robitaille R. Perisynaptic glia discriminate patterns of motor nerve activity and influence plasticity at the neuromuscular junction. *J Neurosci*. **2010**;30(35):11870-82.

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SELEKSIONI KRITERIJUMI U IZBORU PACIJENTA ZA SCS

- hronična neuropatska bol
- neuspjeh konvencionalnog liječenja
- psihološka evaluacija isključuje neko psihijatrijsko oboljenje kao podlogu
- isključena mogućnost drugog hirurškog liječenja
- pacijent je u stanju rukovati scs sistemom, imati razumna očekivanja i biti motivisan
- u trenutku pripreme i provođenja procedure nije u sudskom procesu.

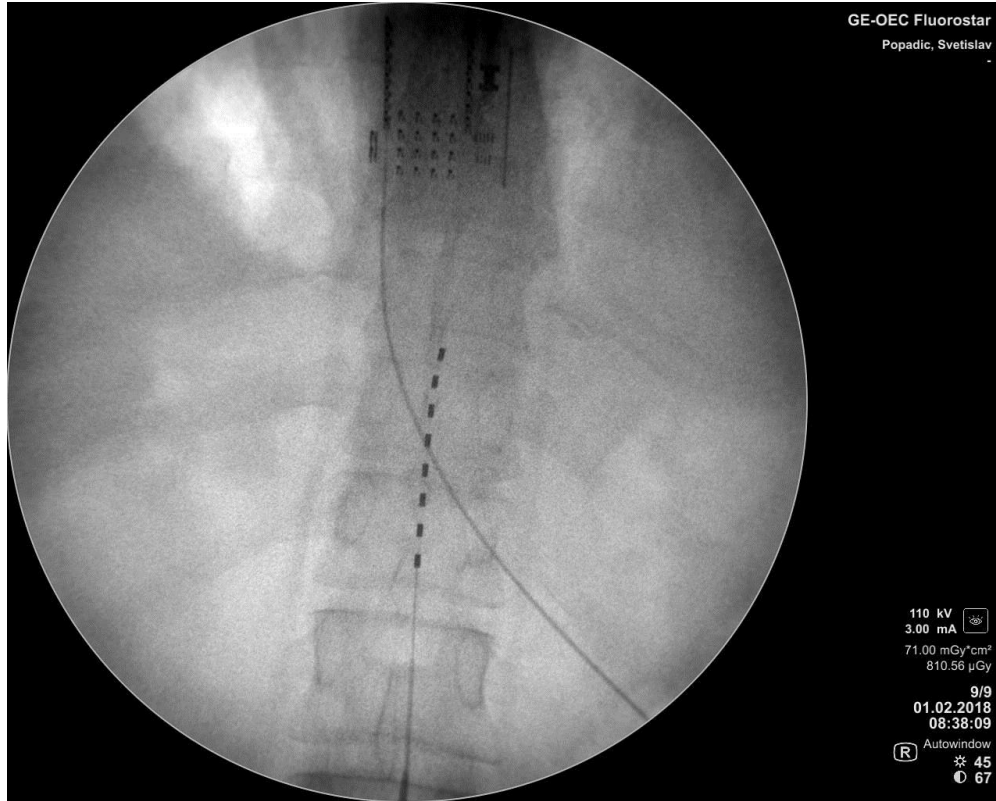
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- NEUROHIRURG
- FIZIJATAR
- PSIHIJATAR
- PSIHOLOG
- SOCIJALNI RADNIK
- KLINIČKI FARMACEUT
- ANESTEZILOG

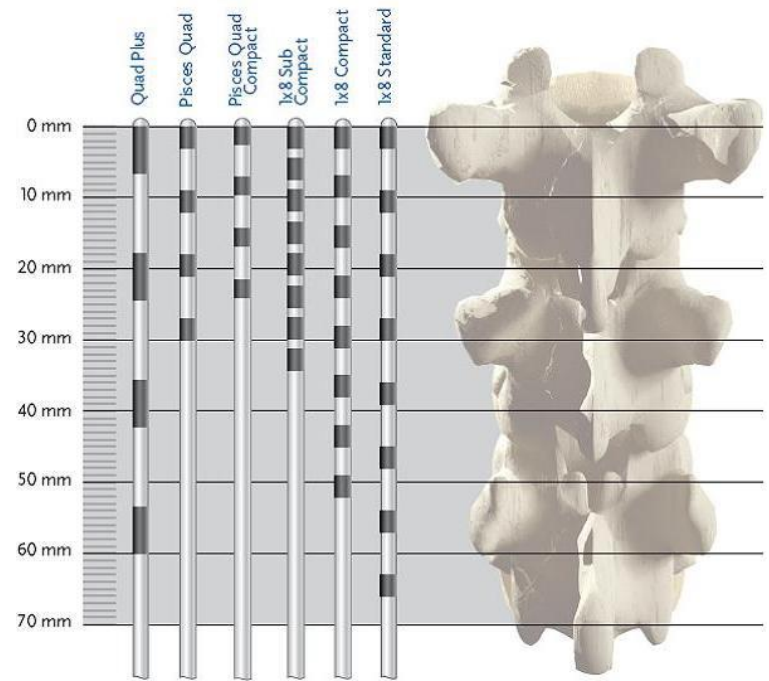


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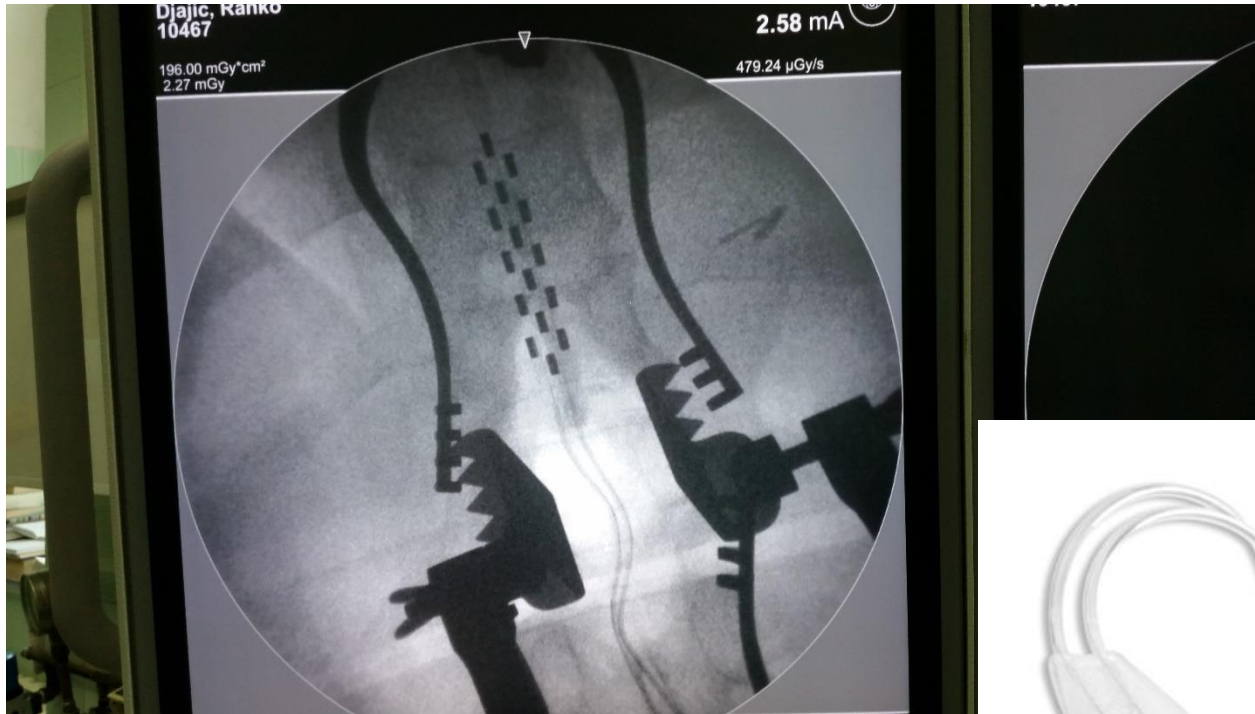


PERKUTANE ELEKTRODE



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HIRURŠKE ELEKTRODE



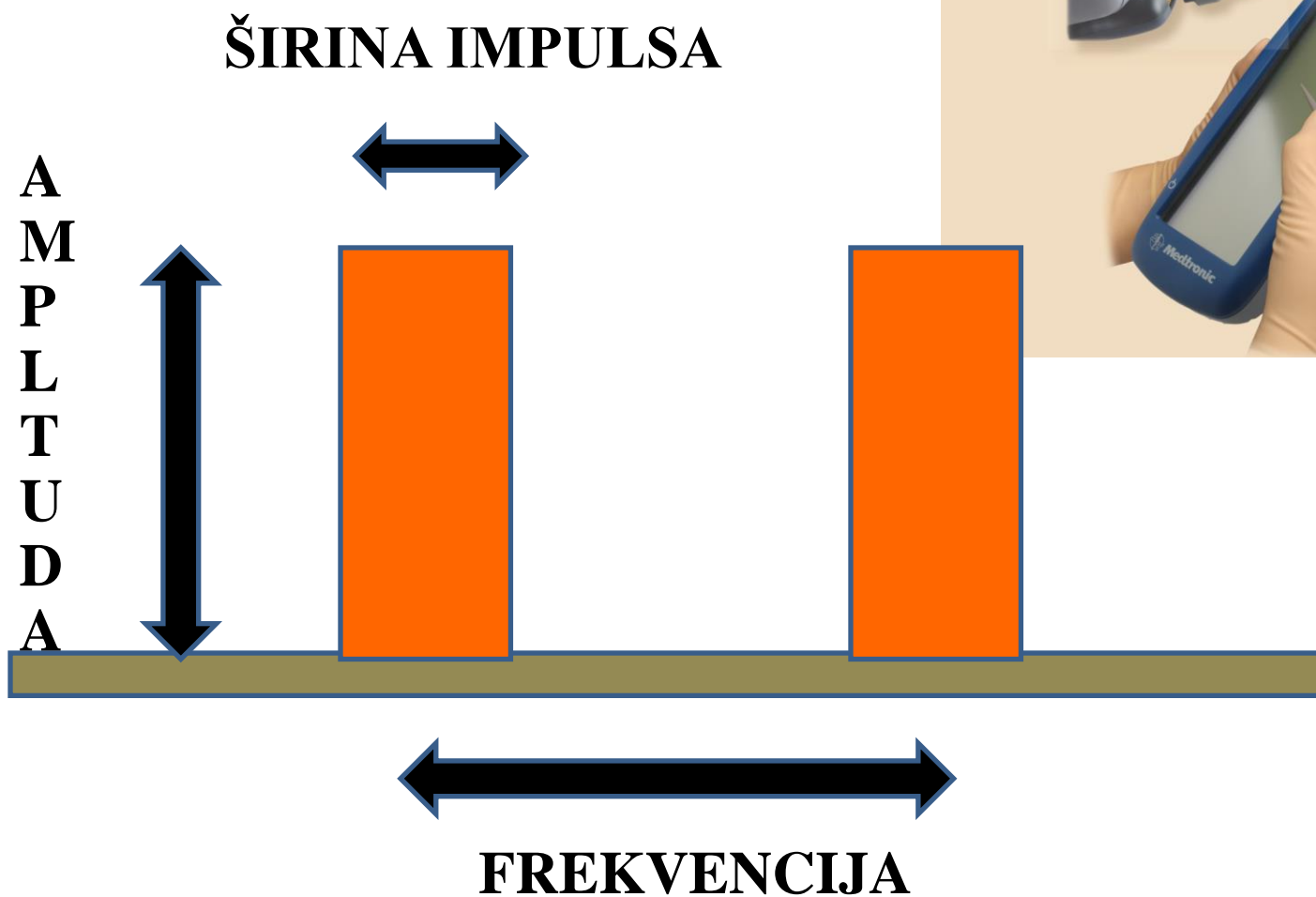
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KOMPLIKACIJE

HARDVERSKJE

Migracija elejtrode, oštećenje elektrode, problemi na lokaciji stimulatora, likvoreja stvara kratki spoja ili električno curenje, visoka ili niska impedanca, istrošena baterija

BIOLOŠKE

Bol, hematom, serom, infekcija, likvoreja, oštećenje kičmene moždine, stimulisana bol, nemogućnost pokrivanja bola, alergija na komponente aparata, progresija oboljenja, nova patologija

KONTRAINDIKACIJA? ILI NE?

CT - ne utiče na sistem, **MR** – 1,5 T

dijagnostički uzv – nije problem (isključiti sistem i pokušati zadržati sondu najmanje 15 cm od sistema)

mamografija – nije problem

pacemaker ili implantirani kardiofibrilator – **pažljivo!**

monopolarna koagulacija – pokušaj izbjeći, ako se i koristi pokušaj izbjeći da koagulaciono polje se ukršta sa neurostimulacionim sistemom

bipolarna koagulacija: preporučeni izbor, međutim pokušaj izbjeći kontakt sa elektrodom

KONTRAINDIKACIJA? ILI NE?

detekcija metala na aerodromu – pokazati identifikacionu karticu, isključiti sistem...

ronjenje – nije problem do dubine od 10m (ili < 2 bar)

skijanje i planinarenje – visina uglavnom ne utiče na sistem

međutim **ekstremni pokreti mogu oštetiti sistem**

NOVI MODALITETI

BURST STIMULATION

HIGH-FREQUENCY STIMULATION

DORSAL ROOT GANGLION STIMULATION

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PRIKAZ SLUČAJA

1. Dg: degenerativna bolest diska, FBSS, 74 godine, penzioner

VAS: 9/10

Oswestry: 74

VAS: 5

Oswestry: 36

2. Dg: postamputacioni neurom, 58 godina, penzioner

VAS: 8

VAS: 1-2

3. Dg: degenerativna bolest diska, FBSS, 48 godina, mašinski tehničar

VAS: 9/10

Oswestry: 84

VAS: 5

Oswestry: 46

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4. Dg: bol nakon povrede kičme i posljedične paraplegije, 35 godina, zaposlena, majka 4-oro djece

VAS: 8/9

VAS: 5/6

5. Dg: degenerativna bolest diska, FBSS, 55 godina, zaposlen

VAS: 8

VAS: 0/1

Oswestry: 64

Oswestry:15

6. Dg: degenerativna bolest diska, FBSS, 58 godina, vozač

VAS: 6

VAS:0

Oswestry: 50

Oswestry:10



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