

Prospective study_of Non-invasive Peripheral Neurostimulation for Pain Management and Rehabilitation following Battlefield Trauma

Bhaskar A¹, Yavorskyy A², Lytsur V², Krekhovetska N², Segin N²
1. Pain Management Centre, Imperial College Healthcare NHS Trust, London, United Kingdom
2. Regional Clinical Hospital of the Ivano-Frankivsk Regional Council, Ivano-Frankivsk, Ukraine

BACKGROUND

The ongoing conflict in Ukraine has produced substantial casualties and severe trauma with limb amputations and extensive tissue injury from blast, shrapnel, and ballistic mechanisms in military personnel. Chronic pain, including phantom limb and neuropathic pain, impedes rehabilitation with limb prosthesis and diminishes quality of life. Due to the ongoing conflict, several therapeutic options are constrained by limited access to interventional modalities and access to opioid analgesics. We are evaluating the use of non-invasive peripheral neuromodulation as a sustainable approach for pain management and rehabilitation facilitation, highlighting its potential to mitigate chronic pain syndromes, improve functional outcomes, and reduce reliance on pharmacologic agents in resource-constrained wartime settings.



MATERIALS AND METHODS

Ethical approval for the study was obtained from the Local Ethics Committee at Ivano-Frankivsk Oblast, Ukraine, on 6 June 2025. A cohort of 48 of 56 participants with heterogeneous chronic pain conditions, predominantly related to amputation and nerve injury, were enrolled in a non-invasive peripheral neurostimulation study in accordance with the protocol. Participants received a single 30-minute session with a patented high-frequency neurostimulation device (Biowave Corp., Norwalk, CT, USA). Stimulation was delivered either as peripheral nerve stimulation or peripheral field stimulation using electrode pads or customized electrode wraps. Stimulation intensity was titrated to a tolerable level that did not produce discomfort, with perceptual attenuation of baseline pain observed during stimulation. Pain intensity was assessed immediately post-treatment and at 24 and 48 hours and compared with baseline values. Functional impact was evaluated by assessing ease of mobilisation with a prosthesis. For participants residing remotely, domiciliary treatment was offered, providing a device for ongoing pain relief and rehabilitation support.

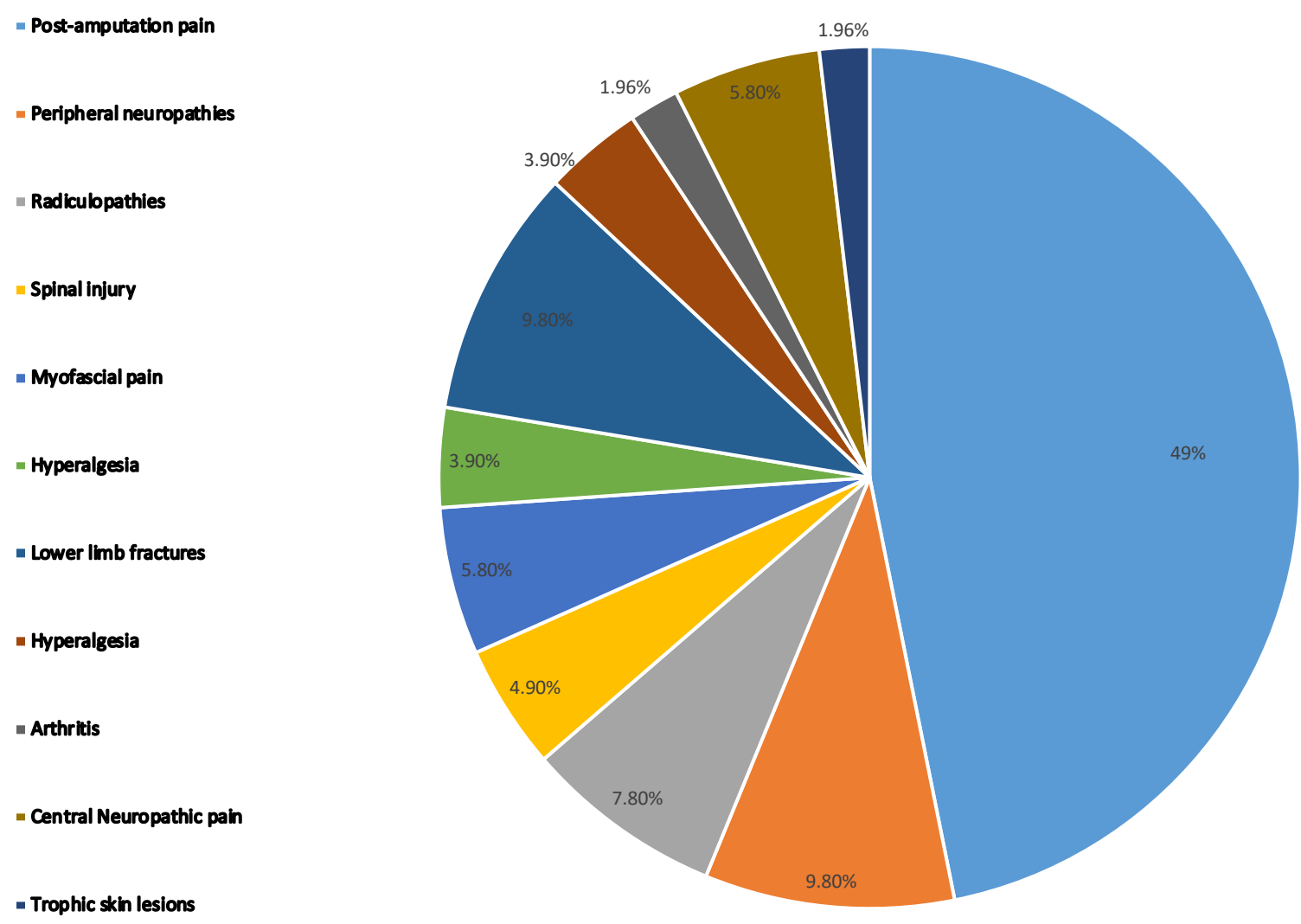
Longitudinal follow-up was conducted monthly via telephone until sustained analgesia was achieved; participants were advised to contact the clinic for additional support or treatments as needed. The study aimed to evaluate the immediate and short-term analgesic effects and functional outcomes associated with non-invasive peripheral neurostimulation in individuals with amputations or nerve injuries related to battlefield injuries.



RESULTS

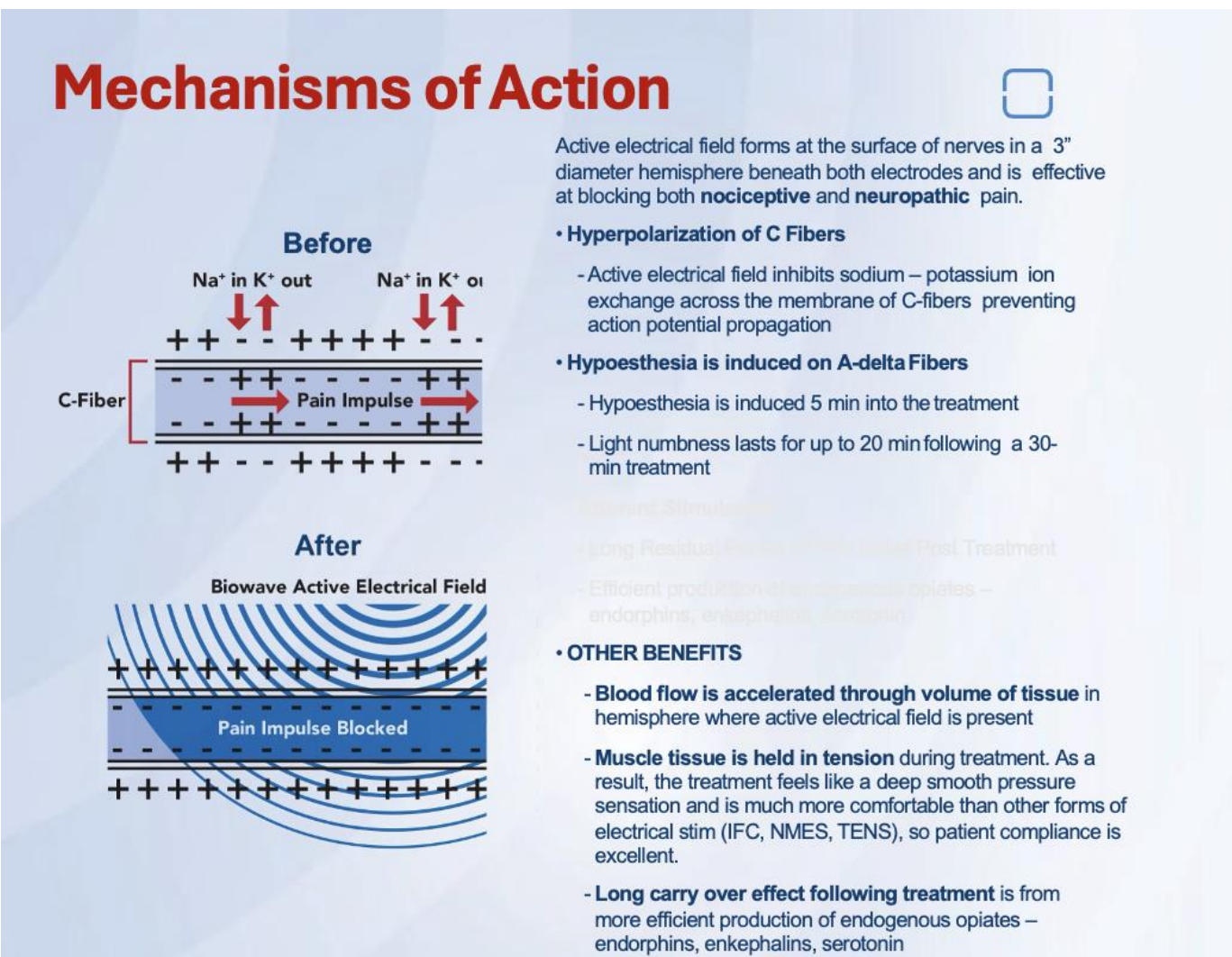
Total patients in the study population: 48
Injured: 44 sustained battlefield injuries
Amputation subgroup: 26 patients with traumatic limb amputations, including bilateral lower-limb amputations and upper-limb amputations
All participants tolerated the stimulation procedure well. A subset required higher stimulation intensities to achieve perceptual and/or therapeutic effects. Intensity was adjusted as per patient preference.
Baseline pain (visual analog scale, VAS) prior to treatment: mean 6.68
Immediately post-treatment: mean 3.24
Short-term follow-up VAS: 24 hours: mean 4.6; 48 hours: mean 5.2
Mean duration of meaningful pain relief: 17.2 hours
Among amputees, a substantial reduction in phantom-limb pain was observed after the initial treatment. Improved mobilisation with prosthetic devices was reported following treatment. Initial patient feedback indicated willingness to continue stimulation therapy for ongoing pain control and rehabilitation facilitation.
Repeat treatments: Fourteen patients underwent repeat stimulation sessions, with effects comparable to the initial treatment.
The intervention demonstrated immediate and short-term reductions in pain with a trend toward increased functional accessibility for prosthetic-assisted mobilisation in amputees and reduced analgesic use.
Prospective, longitudinal data are needed to ascertain sustained analgesic benefits, medication-sparing effects, durable functional improvements and improved quality of life in the long-term.
This data is being collected as part of the long-term follow up.

Conditions Treated



DISCUSSION

The patented electrical stimulation therapy modulates cutaneous electrical delivery by alternating two high-frequency carriers (approximately 3858 Hz and 3980 Hz) between two independent electrodes. As these HF carriers traverse skin and deep tissues, tissue polarization and nonlinear electrodynamics of neuronal and muscular structures generate intermodulation products. The resulting spectrum includes lower-frequency components arising from nonlinear mixing, effectively producing a low frequency (LF) field beneath each electrode. Conceptually, the interaction zone forms a hemispherical region (~3 inches in diameter) that encompasses local nociceptive pathways, potentially modulating axonal excitability and synaptic transmission. The proposed mechanism suggests a electrical field-based interference with nociceptive signal propagation, producing analgesia by reducing peripheral nociceptive input to the central nervous system.



This cohort comprises predominantly military personnel sustaining shrapnel injuries from drone strikes, artillery shelling, and high-velocity gunshot trauma amid the ongoing Ukraine–Russia conflict. We are implementing early intervention to mitigate comorbidity burden and bolster mental health and overall well-being. Plans include expanding the service to additional centres across Ukraine and training health professionals in the delivery of non-invasive neurostimulation. The objective is to monitor progress with a focus on improved mobility, durable pain relief, and reduction and/or tapering of opioid and neuropathic pain medications. We also intend to compare outcomes with analogous studies in veterans from other countries and to explore applicability to civilians undergoing amputations for peripheral vascular disease or diabetes as well as traumatic amputations. Findings will be disseminated in due course.

CONCLUSIONS

Battlefield injuries, including amputations, are typically addressed with prompt initial care; however, post-amputation and other neuropathic pains remain undertreated in many settings. Contributing factors include limited healthcare resources, gaps in specialist expertise, supply chain disruptions, and ongoing conflict, all of which hinder timely rehabilitation, compromise mobilization, exacerbate mood disturbances, and sustain chronic pain. Early integration of non-invasive peripheral neurostimulation into post-amputation pain protocols and broader neuropathic pain management may mitigate these challenges. This approach offers a non-pharmacologic option that can be deployed at the point of care or in remote/low-resource environments, with potential for rapid analgesic benefit, reduced medication burden, and improved functional recovery. The modality is cost-effective, sustainable, scalable, and associated with minimal adverse effects, supporting continued engagement in rehabilitation and quality-of-life improvements.

REFERENCES

- Cohen, S. P., Gilmore, C. A., Rauck, R. L., Lester, D. D., Trainer, R. J., Phan, T., ... & Boggs, J. W. (2019). Percutaneous peripheral nerve stimulation for the treatment of chronic pain following amputation. *Military medicine*, 184(7-8), e267-e274.
- Smith, Brandon J. MD; Twohey, Eric E. MD; Dean, Kaylie P. MD; D'Souza, Ryan S. MD. Peripheral Nerve Stimulation for the Treatment of Postamputation Pain: A Systematic Review. *American Journal of Physical Medicine & Rehabilitation* 102(9):p 846-854, September 2023. | DOI: 10.1097/PHM.0000000000002237
- Albright-Trainer, B., Phan, T., Trainer, R. J., Crosby, N. D., Murphy, D. P., Disalvo, P., ... & Lester, D. D. (2022). Peripheral nerve stimulation for the management of acute and subacute post-amputation pain: a randomized, controlled feasibility trial. *Pain Management*, 12(3), 357-369.
- Rauck, R. L., Cohen, S. P., Gilmore, C. A., North, J. M., Kapural, L., Zang, R. H., ... & Boggs, J. W. (2014). Treatment of post-amputation pain with peripheral nerve stimulation. *Neuromodulation: Technology at the Neural Interface*, 17(2), 188-197.

Acknowledgement

The Biowave Neuromodulation devices and disposables were donated by Biowave Corp. Norwalk, CT 06851 USA for the treatment of injured soldiers in Ukraine.

Contact

Corresponding author: akbhaskar@btinternet.com