



The importance and principles of interventional rehabilitation.

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SUMMARY/ABSTRACT

Interventional rehabilitation is an innovative therapeutic approach that combines targeted interventional techniques with intensive rehabilitation therapy to optimize functional recovery, reduce pain, and speed recovery. This multidisciplinary model uses pharmacological, neuromodulatory and minimally invasive methods in combination with active movement therapy to achieve better therapeutic outcomes than traditional conservative approaches.

Case reports are presented of patients with significant functional limitation of the upper limb in whom interventional rehabilitation resulted in significant improvement in mobility and return to normal daily activities. The results of these cases show that interventional rehabilitation represents an important therapeutic tool in modern medicine. The personalised approach, the precise targeting of therapeutic procedures by ultrasound navigation and the combination of interventional and rehabilitation methods allow the effective and safe management of patients. Thus, interventional rehabilitation provides a bridge between conservative therapy and surgical interventions, while contributing significantly to improved function, pain reduction and overall quality of life for patients.

KEYWORDS

intervention, analgesia, rehabilitation, shoulder joint, wrist joint.

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1 INTRODUCTION

Interventional rehabilitation is a modern multidisciplinary approach to the treatment of patients with musculoskeletal, neurological and chronic pain syndromes. It represents an innovative model that integrates standard elements of conservative therapy (movement therapy, manual techniques, patient education) with targeted invasive or minimally invasive procedures such as pharmacological injections, nerve blocks or neuromodulation. While conservative methods provide a foundational therapeutic framework, their effects are often slower and less specific (Krobot, 2024). In contrast, interventional rehabilitation enables faster pain relief, more precise therapeutic targeting, and a synergistic effect when combined with physiotherapy. This approach represents a significant advancement toward personalized, effective, and evidence-based rehabilitation care. This concept builds upon the latest evidence-based medical knowledge and enables more effective management of both acute and chronic conditions (Berner, J. E. et al., 2024; Mezian, K. et al., 2023; Nakandala, P. et al., 2021; Challoumas, D. et al., 2020; Oshiro, T. et al., 2020; Saranteas, T. et al., 2019; Chang, K. V. et al., 2018; Boyles, R. E. et al., 2005). Interventional rehabilitation encompasses a

wide spectrum of techniques, which can be classified into several main groups. Common interventions include the administration of pharmacological agents (e.g., local anesthetics, corticosteroids, botulinum toxin or platelet-rich plasma – PRP) into joint, periarticular or soft tissue structures (Berner, J. E. et al., 2024). Other methods involve advanced neuromodulatory techniques, including electrical stimulation and radiofrequency ablation, primarily used for chronic pain management (Truong, K., 2024; Gabrhelik et al., 2004). Minimally invasive procedures also play a key role, such as hydrodilatation for adhesive capsulitis, percutaneous neuromodulation and ultrasound-guided nerve blocks (Singh, N. J. et al., 2022; Patel, R. et al., 2020). A key advantage of interventional rehabilitation is its ability to precisely target pathological processes in the musculoskeletal system. This results in faster restoration of functional movement, reduction of pain and overall improvement in patients' quality of life. Integrating interventional techniques into comprehensive rehabilitation programs not only enhances treatment efficacy but also helps prevent secondary complications associated with immobilization and chronic pain syndromes (Horák, S. et al., 2014). Modern clinical practice emphasizes an individualized approach, where each intervention is carefully indicated based on the patient's clinical presentation, imaging findings and expected therapeutic outcomes. Ultrasound-guided navigation plays a crucial role in interventional rehabilitation by ensuring accurate targeting of procedures while minimizing the risk of adverse effects (Mezian, K. et al., 2023; Chang, K. V. et al., 2018). Interventional rehabilitation is often combined with physiotherapeutic techniques, including active movement strategies, manual therapy, robot-assisted rehabilitation and virtual reality, creating a synergistic therapeutic effect (Kirker, K. et al., 2023). Given the growing prevalence of musculoskeletal and neurological disorders, interventional rehabilitation represents a key area of modern medicine, bridging the gap between conservative therapy and surgical intervention. When properly indicated and executed, it can significantly improve clinical outcomes, reduce pain and facilitate a faster return to daily activities and sports performance (Kirker, K. et al., 2023; Horák et al., 2014). The aim of this article is to present the latest trends and approaches in interventional rehabilitation and their application in clinical practice.

2 CASE STUDY

The presented case studies serve as illustrative examples of the application of interventional rehabilitation in patients with functional impairments of the upper limb. The cases were selected based on predefined clinical criteria - specifically, persistent impairment of shoulder joint mobility and persistent wrist mobility dysfunction unresponsive to standard treatment. Both cases meet the conditions for evaluating the effectiveness of combining regional analgesia with targeted rehabilitation in a clinical practice setting. The aim is to demonstrate the efficacy of this approach in a specific context and to link the individual course of treatment with broader therapeutic outcomes.

2.1 CASE STUDY 1: INTERVENTIONAL REHABILITATION OF THE SHOULDER COMPLEX

A 31-year-old female patient was admitted for interventional rehabilitation due to post-traumatic post-contusion adhesive capsulitis of the left shoulder. The injury occurred in June 2023, initially managed with conservative treatment, including pharmacotherapy, one month of orthotic immobilisation, followed by one month of standard outpatient rehabilitation. Due to persistent motion restrictions (flexion and abduction limited to 80°), she underwent an arthroscopic procedure (shaving, manipulation) in September 2023, followed by 1.5 months of outpatient rehabilitation. However, five months post-injury, she continued to experience pain (VAS 5) and significant mobility restrictions (flexion 90°, abduction 80°), leading to the indication for intensive interventional rehabilitation with an interscalene block. The treatment involved a five-day interventional rehabilitation programme combining interventional analgesic therapy with intensive rehabilitation. An ultrasound-guided interscalene analgesic-motor block of the brachial plexus was administered on days 1, 3, and 5. The daily rehabilitation regimen consisted of four sessions: two 45-minute sessions of physiotherapy focusing on manual and movement therapy and two 45-minute sessions of mechanotherapy, including robot-assisted rehabilitation. All interventional procedures were performed using the LOGIQ S7 ultrasound system (GE Healthcare) enabling high-resolution imaging of neural and surrounding anatomical structures for precise needle guidance. The administered medication for the analgesic-motor block was 0.25% Lidocaine with a volume of 20 ml applied perineurally, selected to ensure both sensory

and motor block components while maintaining safety and reversibility. Results showed a significant improvement in shoulder mobility, with flexion increasing from 90° to 170° and abduction from 80° to 165°. Pain intensity, as measured by the visual analogue scale (VAS), was reduced from 5 to 2, and functional abilities improved, particularly in overhead activities. The ADLEIR score (assessing daily activities requiring shoulder function) improved from 30 to 34 points. The patient's social participation was restored - after nine months of sick leave, she returned to her job as a gardener. This case confirms the effectiveness of interventional rehabilitation, which facilitates rapid functional recovery and pain reduction through a combination of regional analgesia and targeted therapy. This multidisciplinary approach minimises systemic side effects and enables a quicker return to daily life.

2.2 CASE STUDY 2: INTERVENTIONAL REHABILITATION FOR A PATIENT WITH WRIST DYS-FUNCTION

A 45-year-old male patient was admitted for interventional rehabilitation due to persistent functional limitations of the right radiocarpal joint following a contusion, with no structural lesions. Post-injury, the patient exhibited significant movement restrictions with a dorsiflexion (DF) of 20°, palmar flexion (PF) of 30°, and ulnar/radial deviation of 5°, resulting in difficulties with daily activities. The treatment protocol combined interventional analgesic therapy with targeted intensive rehabilitation. Three ultrasound-guided reversible analgesic-motor blocks of the median and ulnar nerves were administered weekly, supplemented by an intensive rehabilitation programme conducted twice per week for a total of ten weeks. The rehabilitation included physiotherapy (manual and movement therapy) and mechanotherapy (robot-assisted rehabilitation and functional training). All interventional procedures in this case were also conducted using the LOGIQ S7 ultrasound system (GE Healthcare), ensuring high accuracy of needle placement. The nerve blocks were performed using 0.25% Lidocaine with 10 ml per block, targeting perineural application to achieve optimal sensory and motor blockade. After three months of rehabilitation, wrist mobility significantly improved: DF increased to 60°, PF to 70°, and deviation to 10°, with full restoration of hand function. The patient's functional independence, assessed using the Barthel Index, improved from an initial score of 80 to 95, reflecting a significant enhancement in self-sufficiency. This case further supports the effectiveness of interventional rehabilitation, demonstrating that combining regional analgesia with targeted therapy facilitates the restoration of full movement range and hand function, allowing for a faster return to daily activities.

3 DISCUSSION

Interventional rehabilitation, particularly through analgesic-motor peripheral nerve blocks, represents an evidence-based approach to accelerating functional recovery in patients with musculoskeletal disorders. Its effectiveness is based on a combination of neurophysiological, pharmacological and biomechanical mechanisms. The primary and immediate effect is targeted nociceptive suppression. Local administration of anesthetics into the perineural space blocks afferent pain transmission, thus eliminating one of the main inhibitors of active movement and allowing early engagement of the musculoskeletal system without pain-induced restriction (Saranteas et al., 2019). This effect was also demonstrated in our presented case of a patient with adhesive capsulitis, where the application of the block reduced pain (VAS from 5 to 2) and led to a significant functional gain, objectively reflected by an increase in the ADLEIR score from 30 to 34 points. The ADLEIR score (Activities of Daily Living requiring External and Internal Rotation) is a tool designed to assess the functional capacity of the shoulder joint across twelve common daily activities requiring external and internal rotation. Each activity is rated on a 0–3 scale, with a maximum total score of 36 points. A higher score indicates better functional status (Constant and Murley, 1987). A second important mechanism is the neuromodulatory effect. Repeated stimulation of sensory structures through pharmacological blocks reduces central sensitivity and disrupts the pathological “pain-spasm-pain” cycle, which is particularly relevant in chronic pain conditions and complex regional pain syndrome (CRPS) (Truong et al., 2024; Mezian et al., 2023). These interventions thus exert not only local but also systemic effects at the level of the central nervous system. The third key mechanism is motor relaxation. Temporary blockade of motor fibers allows for safe passive mobilization techniques that would otherwise be painful or technically unfeasible for the patient. This “neurological therapeutic time window” is crucial for correcting pathological movement patterns (Akshara et al., 2022; Boyles et al., 2005). Our findings are fully consistent

with published data. Oshiro et al. (2020) demonstrated the effectiveness of repeated nerve blocks in the treatment of recurrent adhesive capsulitis and highlighted the synergistic effect of regional anesthesia combined with physiotherapy. Similarly, Singh et al. (2022) emphasized the significance of peripheral nerve blocks in CRPS management, reporting significant reductions in pain and improved function. Kirker et al. (2023), in their meta-analysis, confirmed that combining manual therapy with invasive techniques enhances therapeutic outcomes in patients with shoulder joint dysfunctions. Despite its high effectiveness, interventional rehabilitation carries potential risks. The most common complications include transient paresthesias and paresis, which usually resolve spontaneously within 24–72 hours. Rarely, subcutaneous hematomas may occur, particularly in cases of insufficient visualization of vascular structures (Griffin and Nicholls, 2010). In our reported cases, only mild and reversible side effects were observed, without requiring treatment interruption. Limitations include the technical complexity of the procedures, the need for ultrasound guidance, and the experience required of the interventional physician. Contraindications include coagulation disorders, local infections, and allergies to the administered substances. From a health economics perspective, interventional rehabilitation appears to be an efficient strategy that reduces the duration of work incapacity and the need for long-term pharmacotherapy, especially opioid analgesics (Berner et al., 2024). However, its broader availability is currently limited to specialized centers. Successful implementation in routine clinical practice will require systematic staff training and integration of these methods into reimbursement frameworks. The term analgetic-motor blockade refers to a combined pharmacological intervention targeting both sensory and motor fibers of peripheral nerves. The terms analgetic blockade and motor blockade describe the selective suppression of pain or muscle relaxation, respectively. For the purposes of this article, we employ the unified term “interventional rehabilitation” to encompass all described invasive techniques combined with targeted movement therapy. The future of interventional rehabilitation lies in comprehensive personalized care, including AI-driven algorithms for selecting appropriate interventions, robot-assisted therapy, and the development of novel pharmacological agents with prolonged action and higher specificity. Furthermore, large-scale randomized clinical trials are needed to validate therapeutic protocols and enable their integration into standardized practice. All case studies were conducted in accordance with the ethical principles of the Declaration of Helsinki and were approved by the relevant ethics committee. Written informed consent was obtained from all patients for their participation in interventional treatment and the use of anonymized data for scientific purposes.

4 CONCLUSIONS

The presented case studies illustrate the specific clinical benefits of interventional rehabilitation in patients with functional impairments of the upper limb. Both cases demonstrated that targeted analgetic-motor blockade combined with guided physiotherapy leads to measurable improvements in mobility, pain reduction and increased independence in daily activities. However, the conclusions drawn from these case studies should be interpreted with caution they must be understood as part of a broader concept of interventional rehabilitation, the effectiveness of which is supported by current scientific literature. The discussion confirmed that the mechanistic effects of this approach (including neuromodulation, nociceptive interruption, temporary muscle relaxation and therapy facilitation) are consistent with contemporary knowledge in the fields of pain medicine and physiotherapy. Interventional rehabilitation emerges as a promising tool in the treatment of musculoskeletal disorders, deserving further research and systematic integration into clinical practice. Future studies should focus on validating its efficacy in larger patient cohorts, conducting cost-effectiveness analyses and developing standardized protocols. Only through these steps can this approach be sustainably implemented within modern rehabilitation medicine.

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