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Holistic Perioperative Management and Recovery Strategies in Lumbar Spine Surgery: A Comprehensive Review

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Abstract

Background Standard postoperative care in lumbar spine surgery, historically reliant on isolated surgical intervention and prolonged bed rest, is evolving into a comprehensive, multidisciplinary paradigm. This transition is essential to counter the heightened surgical stress and complication risks observed in an increasingly older patient population presenting with multiple comorbidities.

Aim This comprehensive review evaluates the evidence surrounding holistic perioperative management strategies and assesses their combined efficacy in improving clinical and functional outcomes after lumbosacral procedures.

Material and methods A comprehensive systematic literature search was conducted across major academic databases, limiting inclusion to peer-reviewed, English-language studies focusing on adult degenerative lumbar conditions. Data extraction and qualitative synthesis were performed independently by two reviewers adhering to PRISMA guidelines.

Results The implementation of unified care protocols—combining resistance-based prehabilitation, standardized ERAS pathways, targeted nutritional supplementation, and early ambulation—significantly mitigates the physiological stress response. Concurrently, addressing psychological factors like kinesiophobia and anxiety through cognitive interventions lowers postoperative opioid dependence, shortens hospital stays, and reduces overall disability.

Conclusions Successful recovery after lumbar spine stabilization relies on a proactive, biopsychosocial framework rather than isolated structural correction. Integrating physical, metabolic, and psychological care is key to mitigating patient frailty and securing long-term functional independence.

Key words

lumbar spine surgery, perioperative optimization, prehabilitation, early mobilization, ERAS.

Introduction

Lumbar spine surgery, encompassing procedures such as laminectomy and transforaminal lumbar interbody fusion, serves as a critical intervention for chronic radiculopathy and degenerative spinal conditions [1]. While effective for pain relief and functional improvement, these procedures frequently impose significant surgical stress and carry substantial risks of postoperative complications, particularly among an aging demographic with prevalent medical comorbidities [2,3]. Consequently, the traditional surgeon-centered model of care has increasingly transitioned toward a holistic, multidisciplinary perioperative framework [4]. This approach prioritizes proactive preoperative optimization—incorporating structured prehabilitation and comorbidity management—alongside meticulous intraoperative and postoperative strategies to mitigate systemic stress and facilitate recovery [5,6]. By integrating

diverse clinical components, ranging from nutritional support and psychological assessment to early mobilization protocols, clinicians aim to bolster a patient's physiological reserve, thereby minimizing complication rates and fostering more predictable, favorable long-term functional outcomes [7,8]. This review synthesizes the current evidence base regarding these holistic perioperative strategies, evaluating their collective impact on optimizing recovery trajectories following lumbar spine surgery.

Research Materials and Methods

A comprehensive systematic literature search was performed across major academic databases to identify studies addressing perioperative optimization, including prehabilitation, nutritional status, early mobilization, and psychological interventions specifically tailored to patients undergoing lumbar spinal procedures. Inclusion criteria were strictly limited to peer-reviewed, English-language studies evaluating these interventions, while conference abstracts, editorials, and studies focusing on pediatric populations or non-lumbar pathologies were excluded to maintain a rigorous focus on adult degenerative conditions. Data extraction and qualitative synthesis were performed independently by two reviewers, adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines to ensure a structured, objective assessment of the clinical, psychological, and functional recovery outcomes consistently reported across the selected literature.

AI

Artificial intelligence tools were used only for editorial support during manuscript preparation. Their role was limited to linguistic refinement, structural polishing and assistance in reducing repetition. Study selection, interpretation of findings, synthesis of mechanisms and all final scientific conclusions remained under direct human control. AI was not used to generate data or references

Epidemiology and Etiology of Conditions Requiring Lumbar Spine Surgery,

The prevalence of lumbosacral spine disorders, particularly degenerative disc disease, continues to rise alongside the aging global population, with lumbar spinal fusion increasingly utilized as a corrective intervention [\[1\]](#). These degenerative pathologies, including spinal stenosis and herniated discs, impose a significant public health burden by driving progressive declines in physical mobility and overall quality of life [2]. Beyond physical limitations, these conditions are often intertwined with psychological distress; comorbid depression and anxiety

are frequently observed in patients awaiting surgical intervention [9]. Furthermore, the presence of underlying comorbidities—such as cardiovascular disease, malnutrition, and osteoporosis—frequently complicates surgical candidacy, necessitating rigorous preoperative screening to mitigate long-term complications [4]. Consequently, the assessment of frailty has become an essential clinical tool for predicting postoperative complications and gauging a patient's capacity to recover from complex procedures [6,8]. Elevated preoperative frailty scores serve as a critical prognostic indicator, often correlating with adverse clinical outcomes and prolonged recovery trajectories in patients undergoing degenerative spine stabilization [10]. In response to the escalating incidence of conditions such as lumbar spinal stenosis and degenerative spondylolisthesis, clinical practice has increasingly prioritized the refinement of perioperative protocols to support this growing proportion of elderly patients with complex medical needs [2,6]. By systematically addressing these underlying vulnerabilities through multidisciplinary care and rigorous preoperative optimization, clinicians aim to attenuate the systemic surgical stress response, thereby reducing complication rates and fostering more predictable, favorable recovery trajectories [4,8].

Most Common Lumbosacral Spine Surgeries

The surgical management of degenerative lumbar conditions primarily involves decompression techniques and stabilization interventions. Decompression procedures, such as laminectomy and discectomy, are commonly performed to alleviate nerve root impingement by removing structures like herniated disc material or thickened ligamentum flavum. Conversely, stabilization procedures like lumbar spinal fusion are typically indicated for cases of spinal instability or severe degenerative spondylolisthesis, where restoring spinal alignment and structural integrity is paramount [1]. Among these options, transforaminal lumbar interbody fusion has emerged as a particularly prominent intervention for degenerative disc disease, valued for its effectiveness in addressing both mechanical instability and persistent neurological symptoms [1,2]. Ultimately, the selection of the most appropriate surgical modality depends on the specific underlying pathology, patient anatomy, and the presence of concurrent degenerative factors, highlighting the critical need for a tailored, evidence-based approach to ensure optimal long-term functional recovery [11].

Historical Approaches to Post-Operative Rehabilitation

Historically, postoperative care was characterized by extended periods of strict bed rest and activity restriction, rooted in the concern that immobilization was necessary to protect the surgical construct. However, this conventional approach frequently precipitated a spectrum of secondary complications, including muscle atrophy, venous thromboembolism, hypostatic pneumonia, and skin pressure injuries, which significantly hindered recovery and increased morbidity, particularly in elderly populations [12]. Moreover, the lack of early activity often led to delayed functional rehabilitation and exacerbated the psychosocial distress linked to prolonged hospitalization [7,12]. In response, clinical practice has shifted from rigid immobilization toward early mobilization protocols, which have demonstrated significant benefits in reducing hospital length of stay, lowering complication rates, and improving both performance-based and patient-reported outcomes [7,12]. This paradigm shift underscores the critical recognition that early ambulation, when implemented safely, is essential for optimizing long-term functional independence following lumbar spine surgery [11,12].

Holistic Perioperative Strategies

Holistic care in lumbar spine surgery represents a fundamental shift from traditional, surgeon-centered models toward an integrated, patient-centric framework that addresses individual physiological, nutritional, and psychological vulnerabilities [4,9]. This comprehensive approach necessitates sustained multidisciplinary coordination across the preoperative, intraoperative, and postoperative phases to mitigate the systemic surgical stress response, which is a known driver of postoperative morbidity [2,6]. By integrating tailored, multimodal interventions—including structured prehabilitation, personalized nutritional support, and optimized early mobilization protocols—clinicians aim to bolster patient functional reserve, thereby reducing complication rates and fostering more predictable, favorable recovery trajectories [4,8]. This collaborative model, involving surgeons, anesthesiologists, and specialized rehabilitation therapists, ensures that every patient receives a personalized management plan that directly targets specific clinical deficits, ultimately enhancing the overall quality of care and long-term functional outcomes [4,11].

Prehabilitation

Prehabilitation functions as a proactive, multimodal intervention designed to enhance a patient's physiological reserve and functional capacity prior to the surgical insult [8]. This holistic strategy integrates tailored physical exercise programs, nutritional optimization, and behavioral interventions—aimed at mitigating anxiety and bolstering cognitive function—to address the frailty and comorbidities that often complicate recovery in lumbar spine patients [4,8]. While the clinical evidence base for prehabilitation in spine surgery remains in development compared to other surgical disciplines, it offers significant potential to attenuate the systemic physiological stress response, thereby reducing postoperative complications [2,8]. By bridging the interval between the initial surgical decision and the procedure itself, this multidisciplinary approach optimizes baseline health, facilitating a more robust transition to early postoperative mobilization and improving long-term outcomes [4,8]. Clinicians can further customize these protocols by using validated frailty assessments to identify patient-specific deficits, ensuring a more coordinated and personalized perioperative pathway [8]. Central to these effective protocols is progressive resistance training, which serves to bolster core musculature and improve spinal stability and endurance ahead of the surgical intervention.

Enhanced Recovery After Surgery (ERAS) Protocols

The Enhanced Recovery After Surgery protocol marks a paradigm shift in spinal surgery, moving toward a structured, multidisciplinary perioperative care pathway aimed at attenuating the surgical stress response to accelerate functional recovery [2,4]. By standardizing care across preoperative, intraoperative, and postoperative phases, ERAS systematically addresses physiological and psychosocial vulnerabilities—such as malnutrition, glycemic dysregulation, frailty, and uncontrolled comorbidities—that frequently complicate the recovery trajectory [2,6,8]. Core components of these pathways include evidence-based preoperative counseling, optimized nutritional support, and multimodal analgesia strategies designed to minimize opioid reliance [4,6]. Furthermore, the seamless integration of multidisciplinary teams—comprising surgeons, anesthesiologists, and physical therapists—facilitates coordinated care that prioritizes early postoperative ambulation. This unified approach consistently contributes to reduced hospital length of stay, lower complication rates, and enhanced patient-reported outcomes [4,7].

Early Mobilization

Early mobilization is grounded in the physiological necessity to counteract the deleterious effects of prolonged recumbency—such as orthostatic intolerance and skeletal muscle catabolism—by promoting systemic perfusion and neurological activation [\[7,12\]](#). This proactive approach facilitates the restoration of neuromuscular function and improves pulmonary clearance, effectively mitigating serious postoperative complications, including hypostatic pneumonia and venous thromboembolism [\[12\]](#). Safe implementation relies on a standardized, interdisciplinary assessment that carefully calibrates the patient’s comorbidities against the biomechanical requirements of the spinal repair [\[11\]](#). By utilizing tailored, algorithm-based protocols, clinical teams can systematically guide patients through a progressive transition from supervised in-bed conditioning to independent ambulation, thereby aligning recovery with functional milestones and optimizing the postoperative hospital experience [\[11\]](#).

Nutritional Supplementation

Adequate nutritional status is a cornerstone of surgical recovery, providing the metabolic substrates necessary for collagen synthesis and tissue repair. Because preoperative malnutrition is prevalent in lumbar spine surgery patients and is independently associated with higher risks of surgical site infections, medical complications, and prolonged hospital stays, routine screening is imperative [\[13, 14, 15\]](#). Clinical optimization—utilizing validated indices such as serum albumin levels and comprehensive metabolic profiles—enables targeted, evidence-based supplementation that can effectively attenuate the surgical metabolic stress response [\[16, 17\]](#). Research demonstrates that focused perioperative nutritional support not only fosters faster physiological recovery but also reduces overall and wound-related complication rates, thereby maximizing the efficacy of subsequent rehabilitation [\[18,19\]](#). By integrating these nutritional protocols into the perioperative pathway, surgical teams can mitigate the effects of patient frailty and improve long-term functional independence following lumbar spinal procedures [\[16,17\]](#).

Physiotherapy

Targeted physiotherapy interventions are essential for restoring biomechanical integrity and muscle function, with a particular focus on recruiting deep core stabilizers, including the

transversus abdominis and multifidus muscles. These programs typically follow a structured, phased approach, starting with low-load activation—such as gentle stabilization in supine or prone positions—to promote foundational stability while minimizing postoperative pain [20]. As recovery progresses, protocols incorporate more demanding strengthening, balance training, and functional movements to address biomechanical deficits stemming from the underlying pathology and the surgical intervention [21,22]. By tailoring these interventions to the patient's functional status and specific surgical technique, clinical teams can systematically enhance spinal loading tolerance, optimize posture, and facilitate a safer, more efficient return to activities of daily living [22]. Although the optimal timing and modality of formal rehabilitation remain areas of active investigation, structured early-stage mobilization and progressive resistance training are well-supported, correlating with improved functional outcomes and increased physical activity levels during the recovery trajectory [21,23].

Psychological Approach

The integration of psychological care is crucial, as preoperative anxiety and depression are significant predictors of poorer functional recovery and heightened pain sensitivity [24, 25]. These psychological vulnerabilities, frequently manifested through pain catastrophizing—the tendency to ruminate on and magnify the perceived threat of pain—and kinesiophobia, the fear of movement, can profoundly undermine the physiological benefits of successful surgical intervention [26,27]. Given that elevated preoperative anxiety and depression scores correlate with increased postoperative disability, prolonged pain intensity, and diminished patient satisfaction, systematic screening using validated tools—such as the Hospital Anxiety and Depression Scale and the Pain Catastrophizing Scale—is essential [28,29]. To mitigate these deleterious effects, multidisciplinary teams increasingly incorporate psychosocial interventions, including cognitive behavioral therapy, pain coping skills training, and structured patient education, to foster self-efficacy, encourage adaptive cognitive framing, and reduce reliance on postoperative opioids [26, 29, 30]. By addressing these modifiable psychological factors alongside physical and nutritional status, clinicians can adopt a genuinely holistic, biopsychosocial approach that optimizes the perioperative journey and enhances long-term quality of life for patients undergoing lumbar spinal procedures [26, 29].

Conclusions

This review synthesizes the multifaceted evidence supporting a biopsychosocial approach, demonstrating that long-term functional recovery is not merely a consequence of mechanical spinal stabilization, but a synergistic outcome of integrated physical, nutritional, and psychological care [\[17, 26, 29\]](#). By prioritizing preoperative optimization—encompassing targeted nutritional supplementation, structured physiotherapy, and early psychological screening—clinicians can effectively mitigate the deleterious effects of perioperative stress, frailty, and pain catastrophizing [\[16, 18, 19\]](#). Transitioning from traditional, reactive care models to proactive, evidence-based perioperative pathways fosters improved patient-reported outcomes, such as reduced disability and persistent pain, while enhancing the sustainability of surgical success [\[7,11\]](#). Ultimately, adopting this holistic framework shifts the clinical focus from purely anatomical restoration to comprehensive functional preservation, fundamentally enhancing the quality of life for patients undergoing lumbar spinal procedures [\[22, 27, 31\]](#).

Future Perspectives

Future research should prioritize the development of predictive, multi-domain algorithms that integrate demographic, physiological, and biopsychosocial recovery trajectories to create highly personalized, patient-specific care plans [\[32\]](#). By utilizing machine learning to synthesize large, heterogeneous datasets—including preoperative psychological metrics, frailty indices, and real-time data from wearable sensing devices—such models enable clinicians to identify patients at risk of delayed functional recovery or specific complications with greater precision [\[32, 33\]](#). Furthermore, integrating multi-modal, longitudinal data into these predictive frameworks shifts clinical decision-making beyond static patient-reported outcome measures toward a dynamic, data-driven paradigm [\[32\]](#). By leveraging these analytical capabilities, multidisciplinary teams can systematically tailor perioperative interventions to an individual's unique risk profile, thereby maximizing long-term functional independence and holistically optimizing surgical outcomes for an increasingly complex and heterogeneous patient population [\[32, 33\]](#).

Declarations & Statements

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