



CLINICAL AND PATHOMORPHOLOGICAL APPROACHES TO OPTIMIZING
SLEEVE GASTRECTOMY

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Abstract

Sleeve gastrectomy is one of the most widely performed bariatric procedures due to its technical simplicity and favorable metabolic outcomes. However, postoperative complications and variable long-term results indicate the need for optimization of this surgical technique. This study aims to analyze clinical and pathomorphological approaches to optimizing sleeve gastrectomy by integrating patient-related clinical factors with structural and histological characteristics of the gastric wall. The findings demonstrate that individualized surgical planning based on gastric wall morphology, inflammatory status, vascular integrity, and regenerative capacity may significantly reduce complications and improve functional and metabolic outcomes.

Keywords: Sleeve gastrectomy, bariatric surgery, optimization, pathomorphology, gastric wall.

Annotatsiya

Sleeve gastrektomiya texnik jihatdan soddaligi va qulay metabolik natijalari tufayli eng keng qo'llaniladigan bariatrik jarrohlik amaliyotlaridan biridir. Biroq operatsiyadan keyingi asoratlari va uzoq muddatli natijalarning o'zgaruvchanligi ushbu jarrohlik usulini optimallashtirish zarurligini ko'rsatadi. Mazkur tadqiqot sleeve gastrektomiyani optimallashtirishda klinik va patomorfologik yondashuvlarni tahlil qilishga qaratilgan bo'lib, bunda bemorga oid klinik omillar oshqozon devorining strukturaviy va gistologik xususiyatlari bilan uyg'unlashtirilgan. Tadqiqot natijalari oshqozon devori morfologiyasi, yallig'lanish holati, tomirlar yaxlitligi va regenerativ salohiyatiga asoslangan individual jarrohlik rejalashtirish asoratlarni sezilarli darajada kamaytirishi hamda funksional va metabolik natijalarni yaxshilashini ko'rsatdi.

Kalit so'zlar: Sleeve gastrektomiya, bariatrik jarrohlik, optimallashtirish, patomorfologiya, oshqozon devori

Аннотация

Рукавная гастрэктомия является одной из наиболее широко выполняемых бариатрических операций благодаря своей технической простоте и благоприятным метаболическим результатам. Однако послеоперационные осложнения и вариабельность отдалённых результатов указывают на необходимость оптимизации данной хирургической методики. Настоящее исследование направлено на анализ клинических и патоморфологических подходов к оптимизации рукавной гастрэктомии путем интеграции клинических характеристик пациента со структурными и гистологическими особенностями стенки желудка. Полученные результаты показывают, что индивидуализированное хирургическое планирование с учётом морфологии стенки желудка, степени воспаления, состояния сосудистого русла и



регенераторного потенциала тканей может значительно снизить частоту осложнений и улучшить функциональные и метаболические исходы.

Ключевые слова: Рукавная гастрэктомия, бариатрическая хирургия, оптимизация, патоморфология, стенка желудка

Introduction

Sleeve gastrectomy has become one of the most frequently performed bariatric procedures worldwide and is widely accepted as an effective surgical treatment for morbid obesity due to its relative technical simplicity, favorable safety profile, and significant metabolic benefits [1,2]. The procedure achieves weight loss through a combination of restrictive mechanisms and hormonal modulation, primarily by resection of the fundus and greater curvature of the stomach, resulting in reduced gastric volume and decreased ghrelin secretion [3].

Despite its widespread adoption, sleeve gastrectomy is associated with a number of early and late postoperative complications, including staple-line leakage, bleeding, strictures, gastroesophageal reflux disease, and variable long-term weight loss outcomes [4]. These complications suggest that technical standardization alone is insufficient to ensure optimal results. Traditionally, optimization efforts have focused on surgical technique, such as bougie size selection, staple-line reinforcement, and the distance from the pylorus at which resection is initiated [5]. However, growing evidence indicates that patient-specific factors and underlying structural changes of the gastric wall play a critical role in determining postoperative outcomes.

Obesity is a chronic inflammatory condition characterized by systemic metabolic dysregulation, hormonal imbalance, and microvascular dysfunction, all of which contribute to significant remodeling of the gastric wall [6]. Histological studies have demonstrated that obese patients frequently exhibit mucosal hypertrophy, glandular hyperplasia, chronic inflammatory infiltration, fibrosis, and impaired microcirculation within the stomach [7]. These pathomorphological alterations may compromise tissue strength, elasticity, and regenerative capacity, thereby increasing susceptibility to surgical injury and impaired healing following sleeve gastrectomy.

The fundus and greater curvature, which are routinely resected during sleeve gastrectomy, represent regions of the stomach with high endocrine activity and pronounced morphological changes in obesity [8]. Excessive inflammation, vascular congestion, and fibrosis in these areas may predispose patients to staple-line failure, bleeding, and delayed tissue repair. Conversely, excessive resection of relatively preserved gastric segments may disrupt motility and contribute to postoperative functional disorders, including reflux and dysphagia [9].

From a clinical perspective, optimization of sleeve gastrectomy requires a comprehensive approach that integrates preoperative clinical assessment with detailed evaluation of gastric wall morphology. Incorporating endoscopic, histopathological, and, where available, imaging data into surgical planning may allow for individualized determination of resection extent and technique. Such a personalized approach aligns with modern principles of precision surgery and has the potential to improve safety, reduce complication rates, and enhance long-term metabolic outcomes [10].

Therefore, this study aims to evaluate clinical and pathomorphological approaches to optimizing sleeve gastrectomy, emphasizing the role of gastric wall structure and tissue quality in surgical decision-making and postoperative success.

Materials and Methods

This study was designed as a clinical and pathomorphological analysis of patients undergoing sleeve gastrectomy for morbid obesity. Preoperative clinical evaluation included assessment of body mass index, obesity duration, metabolic comorbidities, and gastrointestinal symptoms. Upper gastrointestinal endoscopy was performed to evaluate mucosal integrity and inflammatory changes. Resected gastric specimens obtained during sleeve gastrectomy were fixed in 10% neutral buffered formalin and processed using standard histopathological techniques. Sections were stained with



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hematoxylin and eosin for routine evaluation. Morphological assessment focused on mucosal thickness, glandular architecture, inflammatory cell infiltration, muscular layer integrity, fibrosis, and microvascular alterations. Clinical outcomes and postoperative complications were correlated with histopathological findings to identify morphology-based optimization strategies.

This study was designed as a comprehensive clinical–pathomorphological investigation aimed at optimizing sleeve gastrectomy through integration of patient-specific clinical parameters and detailed assessment of gastric wall morphology. The study included patients diagnosed with morbid obesity who underwent laparoscopic sleeve gastrectomy at a specialized bariatric surgery center. All participants met internationally accepted criteria for bariatric surgery. The study protocol was approved by the institutional ethics committee, and written informed consent was obtained from all patients prior to enrollment.

Preoperative clinical evaluation included collection of demographic data, body mass index, duration of obesity, and assessment of obesity-related comorbidities such as type 2 diabetes mellitus, arterial hypertension, and dyslipidemia. Gastrointestinal symptoms, including dyspepsia and gastroesophageal reflux, were systematically documented. Upper gastrointestinal endoscopy was performed in all patients to assess mucosal integrity, inflammatory changes, and anatomical variations of the stomach. In selected cases, radiological imaging methods were used to evaluate gastric configuration and wall thickness.

Intraoperatively, gastric tissue specimens were obtained from resected segments along the greater curvature and fundic regions during sleeve gastrectomy. Tissue samples were immediately fixed in 10% neutral buffered formalin to preserve structural integrity. Standard histopathological processing was carried out, including dehydration, paraffin embedding, and preparation of serial sections with a thickness of 4–5 μm .

Histological evaluation was performed using hematoxylin and eosin staining for general morphological assessment. In selected samples, additional histochemical staining techniques were applied to better characterize connective tissue remodeling, fibrosis, and vascular structures. Microscopic analysis focused on a layer-by-layer evaluation of the gastric wall, including mucosal thickness, glandular architecture, epithelial proliferative activity, degree of inflammatory cell infiltration, integrity of the muscularis propria, and microvascular alterations such as vascular congestion, capillary dilation, and ischemic changes.

Special attention was given to regional differences within the stomach, particularly between the fundus, body, and greater curvature, which are key anatomical targets in sleeve gastrectomy. Morphological findings were systematically documented and correlated with intraoperative technical factors, including the extent of resection, staple-line positioning, and reinforcement techniques.

Postoperative follow-up included monitoring for early and late complications such as staple-line leakage, bleeding, strictures, and gastroesophageal reflux. Clinical outcomes, including postoperative recovery, complication rates, and early weight loss dynamics, were correlated with preoperative clinical data and histopathological findings. Data analysis was primarily descriptive and analytical, emphasizing clinicopathological correlations rather than purely statistical comparisons.

The collected findings were interpreted to develop morphology-based recommendations for optimizing sleeve gastrectomy, focusing on individualized determination of resection extent, preservation of vascular supply, and minimization of tissue trauma. This integrated methodological approach aimed to establish a rational framework for improving surgical safety and long-term outcomes through clinical and pathomorphological optimization.

Results

Clinical analysis revealed that patients with long-standing obesity and pronounced gastrointestinal symptoms exhibited a higher incidence of postoperative complications. Histopathological examination demonstrated significant variability in gastric wall structure among patients. Pronounced mucosal hypertrophy, glandular hyperplasia, and chronic inflammatory infiltration were frequently



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observed in the fundic and greater curvature regions, which are routinely resected during sleeve gastrectomy.

Microvascular disturbances, including vascular congestion and focal ischemic changes, were associated with an increased risk of staple-line bleeding and delayed healing. In contrast, patients with relatively preserved vascular integrity and lower inflammatory burden demonstrated more favorable postoperative recovery. Excessive fibrosis and muscular disorganization were linked to postoperative strictures and impaired gastric compliance.

Clinical analysis demonstrated substantial heterogeneity among patients undergoing sleeve gastrectomy with respect to obesity duration, severity of metabolic comorbidities, and gastrointestinal symptomatology. Patients with long-standing morbid obesity and pronounced metabolic disturbances more frequently exhibited preoperative gastrointestinal symptoms, including dyspepsia and gastroesophageal reflux. These clinical features were found to correlate with the degree of structural remodeling observed in the gastric wall.

Histopathological examination of resected gastric specimens revealed marked variability in the morphological condition of gastric tissues. In the majority of patients, significant thickening of the gastric mucosa was observed, primarily due to epithelial proliferation and glandular hyperplasia. These changes were most pronounced in the fundic and greater curvature regions, which are the principal targets of resection during sleeve gastrectomy. Chronic inflammatory infiltration of the lamina propria, composed predominantly of lymphocytes and macrophages, was a consistent finding and varied in intensity among patients.

Microvascular alterations were frequently identified and included vascular congestion, capillary dilation, and focal endothelial damage within the submucosal and muscular layers. Patients exhibiting severe microcirculatory disturbances were more likely to experience postoperative complications such as staple-line bleeding and delayed tissue healing. In contrast, specimens with relatively preserved vascular architecture were associated with more favorable early postoperative recovery.

Structural changes within the muscularis propria were also observed. Hypertrophy, disorganization, and focal degeneration of smooth muscle fibers were detected in patients with long-standing obesity and severe mechanical overload. These alterations were associated with reduced gastric compliance and were more commonly observed in patients who later developed postoperative strictures or functional gastric disturbances.

Fibrotic remodeling of the submucosa and muscular layers was evident in a subset of patients. Excessive collagen deposition and loss of normal tissue elasticity were correlated with impaired gastric adaptability and postoperative dysphagia. Conversely, patients with minimal fibrotic changes demonstrated better functional outcomes and fewer late complications.

Correlation analysis between clinical outcomes and morphological findings indicated that patients with pronounced inflammatory, vascular, and fibrotic changes experienced higher rates of postoperative complications, including leakage, bleeding, and functional impairment. In contrast, individualized resection strategies that accounted for tissue quality and regional morphological variability were associated with improved healing, reduced complication rates, and more favorable early weight loss dynamics.

Overall, the results underscore the critical role of gastric wall pathomorphology in determining the safety and effectiveness of sleeve gastrectomy. These findings provide objective morphological criteria that may be used to guide surgical optimization and personalized treatment strategies.

Discussion

The results of this study highlight the importance of integrating clinical and pathomorphological factors into the optimization of sleeve gastrectomy. While technical precision remains essential, the quality of gastric tissues plays a decisive role in determining surgical safety and long-term outcomes. Resection of morphologically compromised gastric segments, particularly those with pronounced inflammation and hypertrophy, appears to be justified both mechanically and endocrinologically.



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At the same time, excessive resection in regions with preserved structure may increase the risk of functional disturbances such as reflux and impaired motility. Therefore, optimization of sleeve gastrectomy should involve individualized assessment of gastric wall morphology to determine resection extent and staple-line positioning. Preservation of adequate vascular supply and minimization of tissue trauma are critical preventive strategies against complications.

The results of the present study highlight that optimization of sleeve gastrectomy cannot be achieved solely through refinement of surgical technique, but must also incorporate a thorough understanding of the clinical and pathomorphological characteristics of the gastric wall. Obesity-related structural remodeling of the stomach creates heterogeneous tissue conditions that significantly influence surgical safety, healing dynamics, and long-term functional outcomes. These findings support the concept that sleeve gastrectomy should be regarded as a biologically guided procedure rather than a uniform technical intervention.

One of the most important observations of this study is the marked variability in gastric wall morphology among obese patients. Pronounced mucosal hypertrophy, glandular hyperplasia, and chronic inflammatory infiltration, particularly in the fundic and greater curvature regions, reflect prolonged functional overload and endocrine hyperactivity. Resection of these morphologically altered areas during sleeve gastrectomy appears to be justified not only for restrictive purposes but also for reducing inflammatory burden and hormonal dysregulation. This may partially explain the favorable metabolic effects observed after adequate fundic resection.

Microvascular alterations identified in this study have significant implications for surgical outcomes. Vascular congestion, endothelial dysfunction, and focal ischemic changes compromise tissue perfusion and oxygen delivery, thereby increasing the risk of staple-line bleeding, leakage, and delayed healing. These findings underscore the importance of preserving adequate vascular supply and minimizing excessive thermal or mechanical trauma during surgery. Optimization strategies should therefore emphasize careful tissue handling, appropriate staple selection, and avoidance of excessive tension along the staple line.

Fibrotic remodeling and muscular layer disorganization were closely associated with postoperative strictures and impaired gastric compliance. Excessive fibrosis reduces tissue elasticity and adaptive capacity, potentially leading to functional obstruction and dysphagia. These observations suggest that overly aggressive resection in regions with advanced fibrosis may exacerbate functional complications. Consequently, a balance must be achieved between sufficient resection of pathologically altered tissue and preservation of structurally competent gastric segments to maintain physiological motility.

From a clinical standpoint, integration of preoperative endoscopic findings with intraoperative morphological assessment may significantly improve risk stratification and surgical planning. Patients with severe inflammatory and vascular changes may benefit from tailored resection strategies, enhanced staple-line reinforcement, and intensified postoperative monitoring. Such an individualized approach aligns with the principles of precision surgery and may contribute to reduced complication rates and improved patient satisfaction.

Overall, this discussion emphasizes that sleeve gastrectomy outcomes are determined by a complex interaction between technical factors and tissue biology. Recognition of gastric wall pathomorphology as a key determinant of surgical success provides a scientific basis for optimizing sleeve gastrectomy. Future research should focus on developing standardized morphology-based algorithms, incorporating quantitative histomorphometry, advanced imaging, and molecular markers of inflammation and regeneration. Such advances may further refine personalized approaches to sleeve gastrectomy and improve both short- and long-term outcomes.

Conclusion

Optimization of sleeve gastrectomy requires a comprehensive approach that combines clinical evaluation with detailed pathomorphological assessment of the gastric wall. Structural changes such



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as chronic inflammation, microvascular dysfunction, fibrosis, and impaired regenerative capacity significantly influence postoperative outcomes. Incorporating morphology-based criteria into surgical planning may reduce complication rates, improve healing, and enhance long-term metabolic and functional results. Future studies integrating molecular and immunohistochemical analyses are warranted to further refine personalized strategies for sleeve gastrectomy optimization.

The findings of this study demonstrate that successful optimization of sleeve gastrectomy requires an integrated clinical and pathomorphological approach rather than reliance on technical standardization alone. While surgical technique remains a critical determinant of outcomes, the structural and functional condition of the gastric wall plays a decisive role in postoperative safety, healing capacity, and long-term metabolic effectiveness. Obesity-related pathological remodeling of gastric tissues—including chronic inflammation, microvascular dysfunction, fibrosis, and altered regenerative potential—creates a biological substrate that directly influences the risk of complications and functional disturbances following sleeve gastrectomy.

Morphological assessment of the stomach provides a rational basis for individualized surgical planning. Resection of gastric segments exhibiting pronounced hypertrophy, inflammatory infiltration, and vascular compromise is justified not only to achieve restrictive and endocrine effects but also to reduce the likelihood of staple-line failure and delayed healing. Conversely, preservation of relatively intact gastric regions with adequate vascularization and muscular integrity is essential for maintaining physiological motility and minimizing postoperative complications such as gastroesophageal reflux and strictures.

From a clinical perspective, incorporation of preoperative endoscopic evaluation and histopathological analysis into routine assessment allows for more accurate identification of high-risk tissue characteristics. This information may guide critical intraoperative decisions, including the extent of resection, staple-line positioning, and reinforcement strategies. Furthermore, recognition of patient-specific morphological variability supports a personalized surgical approach, aligning sleeve gastrectomy with the principles of precision medicine.

In conclusion, optimization of sleeve gastrectomy should be based on a comprehensive understanding of both clinical factors and gastric wall pathomorphology. Such an integrated strategy has the potential to reduce postoperative complication rates, improve tissue healing, and enhance long-term weight loss and metabolic outcomes. Future studies incorporating advanced imaging techniques, quantitative morphometric analysis, and molecular markers of inflammation and regeneration are warranted to further refine morphology-guided approaches and establish standardized criteria for personalized optimization of sleeve gastrectomy.

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