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**CLINICAL AND PATHOMORPHOLOGICAL BASES FOR OPTIMIZING GASTRIC
RESECTION IN BARIATRIC SURGERY**

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ANNOTATION

Optimization of gastric resection in bariatric surgery requires an integrative evaluation of clinical, anatomical, functional, and pathomorphological characteristics of the stomach. Modern bariatric approaches increasingly emphasize not only the restrictive component of sleeve gastrectomy but also its metabolic and hormonal impacts, which depend on the microstructure of gastric mucosa, endocrine cell distribution, vascular architecture, and muscular morphology. This article provides a comprehensive analysis of the clinical and pathomorphological foundations that determine optimal resection boundaries, including the extent of fundic excision, antral preservation, stapling trajectory, and prevention of postoperative functional stenosis. Particular attention is given to endocrine factors (e.g., ghrelin secretion zones), mechanisms of gastroesophageal reflux exacerbation, and structural variations influencing postoperative outcomes. Based on evidence from recent clinical and morphologic research, key recommendations are formulated for individualized surgical planning. The article highlights how a pathomorphology-guided, patient-specific resection strategy can enhance weight-loss sustainability, reduce complications, and improve long-term metabolic results.

Keywords: bariatric surgery, sleeve gastrectomy, gastric resection, stomach anatomy, pathomorphology, fundus, antrum, GERD, obesity treatment.

**КЛИНИКО- И ПАТОМОРФОЛОГИЧЕСКИЕ ОСНОВЫ ОПТИМИЗАЦИИ
РЕЗЕКЦИИ ЖЕЛУДКА В БАРИАТРИЧЕСКОЙ ХИРУРГИИ**

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АННОТАЦИЯ

Оптимизация резекции желудка в бариатрической хирургии требует комплексной оценки клинических, анатомических, функциональных и патоморфологических характеристик желудка. Современные бариатрические подходы акцентируют внимание не только на рестриктивном компоненте продольной резекции желудка, но и на её метаболических и гормональных эффектах, которые зависят от микроструктуры слизистой



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оболочки, распределения эндокринных клеток, сосудистой архитектуры и морфологии мышечного слоя. В данной статье представлен всесторонний анализ клинических и патоморфологических основ, определяющих оптимальные границы резекции, включая объем удаления дна желудка, сохранение антрума, направление линии сшивания и профилактику послеоперационного функционального стеноза. Особое внимание уделено эндокринным факторам (например, зонам секреции грелина), механизмам усиления гастроэзофагеального рефлюкса и структурным вариациям, влияющим на послеоперационные результаты. На основе современных клинко-морфологических данных сформулированы ключевые рекомендации для индивидуализированного планирования операции. Статья подчеркивает, что патоморфологически ориентированная, персонализированная стратегия резекции позволяет повысить устойчивость снижения массы тела, уменьшить количество осложнений и улучшить долгосрочные метаболические результаты.

Ключевые слова: бариатрическая хирургия, продольная резекция желудка, резекция желудка, анатомия желудка, патоморфология, дно желудка, анtrum, ГЭРБ, лечение ожирения.

BARIATRIK JARROHLIKDA ME‘DA REZEKTSIYASINI OPTIMALLASHTIRISHNING KLINIK VA PATOMORFOLOGIK ASOSLARI

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ANNOTATSIYA

Bariatrik jarrohlikda me‘da rezektsiyasini optimallashtirish klinik, anatomik, funksional va patomorfologik xususiyatlarning kompleks tahlilini talab qiladi. Zamonaviy bariatrik yondashuvlar sleeve-gastrektomiyaning faqat restriktiv ta‘sirini emas, balki uning metabolik va gormonal natijalarini ham muhim deb hisoblaydi. Bu jarayonlar me‘da shilliq qavati mikrostrukturasiga, endokrin hujayralar taqsimotiga, qon tomirlar arxitekturasiga va mushak qatlamining morfologik tuzilishiga bog‘liq. Ushbu maqolada optimal rezektsiya chegaralarini belgilaydigan klinik va patomorfologik omillar – fundusni to‘liq olib tashlash darajasi, antrumni saqlash, stapler yo‘nalishi va operatsiyadan keyingi funksional stenozning oldini olish – batafsil tahlil qilinadi. Grelin ajraladigan zonalar kabi endokrin faktorlar, gastroezofageal reflyuks kuchayish mexanizmlari va natijaga ta‘sir qiluvchi anatomik-funksional farqlar alohida yoritiladi. So‘nggi klinik va morfologik tadqiqotlar asosida individual jarrohlik rejasini shakllantirish uchun tavsiyalar ishlab chiqilgan. Maqola patomorfologiyaga asoslangan, bemorga moslashtirilgan rezektsiya strategiyasi vazn yo‘qotishning barqarorligini oshirish, asoratlarni sonini kamaytirish va uzoq muddatli metabolik natijalarni yaxshilashini ko‘rsatadi.

Kalit so‘zlar: bariatrik jarrohlik, sleeve-gastrektomiya, me‘da rezektsiyasi, me‘da anatomiyasi, patomorfologiya, fundus, antrum, GERO, semirishni davolash.

INTRODUCTION

Bariatric surgery has become the most effective treatment modality for morbid obesity and obesity-associated metabolic diseases, including type 2 diabetes mellitus, metabolic syndrome, and non-alcoholic fatty liver disease. Over the past two decades, laparoscopic sleeve gastrectomy (LSG) has evolved from a component of biliopancreatic diversion to an independent metabolic procedure and is now the most frequently performed bariatric operation worldwide [1,2]. Despite its widespread adoption, considerable variability exists in surgical technique, including differences in the extent of fundic resection, antral preservation, stapling line trajectory, bougie calibration diameter, and hiatal dissection. These technical variations may significantly influence postoperative outcomes such as



gastroesophageal reflux, gastric emptying, weight-loss dynamics, and rates of functional stenosis or staple-line leaks [3,4].

A growing body of evidence suggests that sleeve gastrectomy should be conceptualized not merely as a restrictive intervention but as a complex metabolic-hormonal operation. The stomach plays a central role in endocrine regulation through ghrelin, leptin, motilin, somatostatin, and GLP-1—modulating pathways. The fundus, with its high density of ghrelin-producing X/A-like cells, is of particular significance in appetite and energy homeostasis, making its complete resection critical for optimal metabolic response [5]. Pathomorphological studies demonstrate that insufficient fundic excision or retained gastric pouches may lead to suboptimal hormonal suppression and early weight regain [6].

The antrum contributes substantially to gastric motility through its hypertrophic muscular layers and plays a key role in propulsive peristalsis. Over-resection of the antrum may impair gastric emptying and increase intraluminal pressure, whereas excessive preservation may blunt weight-loss effects [7]. Similarly, the incisura angularis has been identified as a structural “risk zone” due to its natural anatomical angulation; aggressive resection in this region predisposes to mid-sleeve stenosis, whereas insufficient narrowing reduces restriction [8].

Pathomorphological analysis of the gastric wall—including mucosal integrity, lymphoid infiltration, fibrosis, muscular hypertrophy, vascular architecture, and micro-inflammatory changes—has become essential for tailoring resection margins and preventing complications [9]. Moreover, the presence of hiatal hernias, laxity of the phrenoesophageal ligament, and specific esophageal-gastric angle configurations significantly contribute to postoperative gastroesophageal reflux, demanding individualized intraoperative management [10].

In this context, integrating clinical data, endoscopic findings, and pathomorphological indicators provides a more precise foundation for optimizing the surgical technique. The present article synthesizes current evidence to formulate clinical-pathomorphological guidelines for improving gastric resection in bariatric surgery, emphasizing a personalized, anatomy-driven, and evidence-based approach.

Literature Review

The review of the literature demonstrates that the optimization of gastric resection in bariatric surgery is grounded in a rapidly expanding body of scientific evidence that integrates clinical outcomes, endocrine physiology, and gastric pathomorphology. According to Angrisani et al. (2021), sleeve gastrectomy has become the most commonly performed bariatric procedure worldwide, which highlights the importance of developing evidence-based standards for technique refinement and surgical precision. The global expansion of LSG underscores the need to better understand anatomical details that influence long-term effectiveness. Complementing these findings, Himpens et al. (2020) describe the evolution of bariatric surgery as a field increasingly focused on metabolic effects rather than simple mechanical restriction. Their work supports the view that gastric resection must consider hormonal zones such as the ghrelin-secreting fundus.

The question of whether sleeve gastrectomy is primarily restrictive or metabolic is further discussed by Melissas et al. (2007), who show that the removal of the fundus alters hormonal signals related to hunger and satiety. Their research provides early physiological justification for the complete fundic resection principle. Similarly, Soricelli et al. (2013) emphasize that small technical variations—particularly in the stapling line and resection boundaries—strongly influence post-operative outcomes such as reflux and stenosis. Their findings reinforce the need for standardizing key operative steps.

Cummings and Foster-Schubert (2014) provide deeper insight into ghrelin physiology, explaining why incomplete removal of the fundic endocrine zone can undermine weight-loss outcomes. Their work explains the biological basis for the surgical findings reported in clinical studies. Ahn et al. (2019) further confirm this association by demonstrating that residual fundic tissue



correlates with inadequate weight loss and early weight regain. Together, these studies establish a clear relationship between anatomical precision and metabolic success.

Antral function is another major element of optimal resection. Nocca et al. (2016) illustrate how the antrum contributes significantly to gastric motility and emptying, arguing that excessive antral resection leads to delayed emptying and elevated intragastric pressure. Their findings strongly support preserving a carefully measured length of the antrum. In parallel, research by El Chaar et al. (2011) highlights the importance of respecting the anatomical configuration of the incisura angularis. They show that this region is prone to stenosis when stapling deviates from the natural axis of curvature.

Pathomorphological changes in the stomach wall have also been documented as critical. Basso et al. (2019) identify chronic inflammation, mucosal hypertrophy, and fibrosis as structural factors that increase complication risk during sleeve formation. Their observations support the idea that pre-operative assessment of gastric wall characteristics can improve surgical planning and reduce postoperative leaks. Finally, Soricelli et al. (2020) present evidence that hiatal defects must be evaluated and repaired during surgery to prevent postoperative reflux. Their findings extend the understanding of postoperative GERD beyond sleeve shape alone and highlight the interaction between gastric and esophageal anatomy.

Overall, these ten studies collectively demonstrate that successful optimization of gastric resection requires integrating clinical technique with anatomical precision and pathomorphological awareness. The literature consistently supports a shift from a uniform technical approach toward a personalized, anatomy-based surgical strategy.

Methods

The methodological basis of this article consists of a structured analysis of scientific publications, clinical observations, and anatomical descriptions related to bariatric surgery and gastric morphology. The material for the study includes data from contemporary research on sleeve gastrectomy, focusing on how surgical decisions influence metabolic outcomes, complication rates, and anatomical integrity. The analysis relies on descriptions of the functional anatomy of the stomach, including the structure of the fundus, the muscular organization of the antrum, the natural narrowing at the incisura angularis, and the characteristics of the gastric wall such as mucosal thickness, vascular patterns, and connective tissue distribution. These anatomical and morphological features were compared with documented variations in surgical technique, including bougie calibration diameter, stapling line trajectory, extent of fundic excision, antral preservation, and management of the hiatal region.

Clinical data from published studies were examined to evaluate postoperative results such as weight-loss dynamics, incidence of gastroesophageal reflux, development of stenosis, leak rates, and changes in appetite-regulating hormones. Reports describing the impact of incomplete fundus removal, excessive narrowing at the incisura, or inappropriate antral resection were used to understand the relationship between technical choices and clinical consequences. Comparative descriptions of different sleeve designs were reviewed to identify how variations in gastric tube shape, diameter, and residual volume affect long-term efficacy and safety.

To synthesize the evidence, information extracted from anatomical sources and clinical studies was integrated into a unified conceptual framework. This framework connects structural characteristics of the stomach with surgical decisions and postoperative outcomes. Through this approach, general principles were formulated for optimizing gastric resection, emphasizing the importance of complete fundus removal, balanced antral preservation, avoidance of excessive narrowing, and identification of hiatal abnormalities. The methods applied allowed the development of practical, clinically grounded recommendations aimed at improving the safety and functional effectiveness of bariatric surgery.



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Results

The analysis of anatomical and clinical data demonstrated that the effectiveness of gastric resection in bariatric surgery is closely dependent on several key structural and functional characteristics of the stomach. The review showed that complete removal of the fundus consistently leads to improved appetite regulation and more stable reductions in body weight, confirming the central role of ghrelin-producing cells in the metabolic response to sleeve gastrectomy. Studies describing partial or incomplete fundic resection reported weaker hormonal suppression and a higher likelihood of early weight regain, indicating that surgical precision in this area plays a critical role in long-term outcomes.

Evaluation of the antral region revealed that the degree of preservation of the antrum strongly influences postoperative gastric motility. When the antrum is excessively shortened, patients tend to develop symptoms of delayed emptying, increased intragastric pressure, and postoperative discomfort. In contrast, adequate preservation of the antrum supports coordinated contractile activity and promotes more physiological food transit. However, overly generous antral preservation was associated with a reduced restrictive effect and slower weight-loss progress, suggesting the need for a balanced approach based on morphological assessment.

The analysis of the stapling line and the shape of the gastric tube demonstrated that variations in trajectory can significantly impact the risk of stenosis and functional obstruction. A consistent finding across clinical reports was that narrowing at the incisura angularis often results from over-resection or sharply angled stapling, producing a twisted or hourglass-shaped sleeve. Such configuration increases the risk of postoperative vomiting, dysphagia, and intolerance to solid food. Conversely, a straight, uniform sleeve showed lower rates of stenosis and better long-term tolerance.

The review also demonstrated a clear relationship between gastric wall structure and postoperative complications. Thickened or fibrotic gastric tissue, prominent adipose infiltration along the greater curvature, and increased vascular density were identified as factors that elevate the risk of stapling difficulties and staple-line leaks. These morphological features tended to be more pronounced in patients with chronic inflammation or long-standing obesity, underscoring the necessity of individualized surgical planning.

Hiatal anatomy was found to be another important determinant of postoperative results. Patients with pre-existing hiatal hernias or weakness of the phrenoesophageal ligament showed a higher incidence of postoperative gastroesophageal reflux when the hiatal region was not adequately addressed during surgery. When hiatal repair was performed concomitantly with sleeve gastrectomy, reflux symptoms were significantly reduced, and overall patient satisfaction improved. This finding highlights the role of comprehensive anatomical evaluation rather than focusing solely on gastric volume reduction.

Across all examined studies, a consistent pattern emerged: surgical outcomes improved when resection boundaries and sleeve configuration were adjusted according to specific anatomical and pathomorphological characteristics. Patients receiving techniques that incorporated careful fundic excision, controlled antral preservation, straight stapling lines, and correction of hiatal abnormalities demonstrated better tolerance, lower complication rates, and more stable long-term weight loss. These results support the concept that gastric resection optimization should be guided by detailed anatomical knowledge and individualized assessment rather than a uniform technical approach.

Discussion

The findings of this analysis support the growing understanding that gastric resection in bariatric surgery functions as a metabolic and anatomical intervention rather than a purely restrictive procedure. The results confirm that the success of sleeve gastrectomy depends on respecting the structural complexity of the stomach and recognizing how its individual regions contribute to hormonal regulation, motility, and postoperative function. The consistent evidence that complete fundus removal enhances weight-loss outcomes reinforces the central role of the fundic endocrine



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zone, particularly the suppression of ghrelin secretion. This emphasizes that even slight variations in fundic dissection can alter metabolic response, making precision in this area one of the most important factors for optimizing results.

The significance of antral preservation also emerges as a crucial determinant of postoperative physiology. The antrum's contribution to gastric emptying means that its over-resection can negatively affect functional motility, while under-resection may compromise the restrictive effect. This dual impact suggests that uniform surgical templates may be inadequate and that surgeons should adjust antral length based on individual anatomical features such as muscular thickness, degree of fibrosis, and preoperative motility characteristics. The results indicate that balanced antral preservation contributes substantially to patient comfort, tolerance of solid food, and avoidance of high-pressure complications.

Variations in stapling line design and gastric tube configuration further underscore the importance of an individualized surgical approach. The high frequency of functional stenosis at the incisura angularis reported in the literature highlights this region as a natural anatomical bottleneck. When surgical technique disregards this feature, the risk of creating a twisted sleeve increases markedly. The discussion of these findings demonstrates that a consistently straight and evenly calibrated tube is essential for minimizing postoperative obstruction and reducing revision surgery rates.

The role of pathomorphological changes in influencing complication risk also becomes clearer when integrating the findings. Chronic inflammation, mucosal hypertrophy, and submucosal fibrosis, commonly present in patients with long-standing obesity or gastritis, appear to increase the likelihood of staple-line leaks and mechanical difficulties during resection. These results highlight the value of preoperative assessment, including endoscopic and imaging evaluations, to identify structural abnormalities that may require modification of surgical technique. Such adjustments may include changing the stapler load, altering resection margins, or reinforcing high-risk areas.

The analysis also emphasizes the importance of evaluating the hiatal region. Postoperative gastroesophageal reflux remains one of the most frequent concerns after sleeve gastrectomy. The finding that reflux rates decrease significantly when hiatal repair is performed during surgery underscores the need for systematic assessment of the esophagogastric junction. This supports the view that reflux is not solely a consequence of sleeve shape but also influenced by pre-existing anatomical weaknesses that should be corrected intraoperatively.

Taken together, these findings reinforce the need for personalized bariatric surgery that adapts to the unique anatomical and pathomorphological features of each patient. Standardized techniques may provide acceptable average results, but the evidence shows that individualized modifications lead to superior safety, reduced complications, and improved long-term weight-loss maintenance. The discussion highlights that the most successful surgical outcomes arise when the operation is guided by detailed anatomical understanding, careful intraoperative assessment, and a willingness to adjust technical steps according to patient-specific factors. This individualized approach aligns with the broader shift in modern bariatric surgery toward precision-based, multidisciplinary care focused on maximizing therapeutic benefit while minimizing postoperative risks.

Conclusion

The results of this analysis clearly demonstrate that the optimization of gastric resection in bariatric surgery must be grounded in a deep understanding of the stomach's anatomical and pathomorphological characteristics. The evidence confirms that the stomach cannot be treated as a uniform structure; rather, each of its regions plays a specific functional and metabolic role that directly influences the outcomes of sleeve gastrectomy. The consistent superiority of techniques involving complete fundus removal highlights the importance of endocrine regulation in appetite suppression and metabolic improvement. Conversely, insufficient fundic excision repeatedly leads to inadequate hormonal response and diminished long-term weight-loss durability.



The findings also emphasize that the antrum is not merely a mechanical component of the stomach but a critical regulator of gastric motility. Balanced antral preservation supports more physiological emptying patterns, reduces intragastric pressure, and enhances patient comfort after surgery. At the same time, preserving an excessive portion of the antrum compromises the restrictive effect of the procedure, underlining the necessity of individualized decision-making rather than adherence to a fixed operative template.

The data related to stapling-line trajectory and gastric tube geometry demonstrate that anatomical awareness is essential for avoiding functional stenosis and postoperative obstruction. Complications such as incisura narrowing result not from the procedure itself but from technical imprecision that disregards natural anatomical angulation. The creation of a uniform, straight sleeve appears to be a crucial factor in achieving stable postoperative function.

Pathomorphological variations of the gastric wall, including inflammation, fibrosis, and increased adipose infiltration, further show that patient-specific structural differences significantly affect complication risks. Recognition of these factors before and during surgery allows the surgeon to modify resection technique and improve tissue handling, leading to safer outcomes. Similarly, the strong association between hiatal abnormalities and postoperative reflux indicates that optimal bariatric surgery extends beyond gastric shaping and must include a systematic assessment of the esophagogastric junction.

Collectively, these findings support a shift from standardized bariatric surgery toward a more precise, anatomy-driven, and individualized approach. The integration of clinical assessment, anatomical understanding, and pathomorphological evaluation provides the basis for surgical techniques that are not only more effective in promoting long-term weight control but also safer and more tolerable for patients. The conclusion emerging from this analysis is that successful optimization of gastric resection relies on tailoring the operation to the specific structural and functional characteristics of each patient rather than applying a universal technique. As bariatric surgery continues to evolve, such personalized strategies hold the greatest promise for maximizing therapeutic outcomes and minimizing the risk of postoperative complications.

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