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The Evolving Role of Bariatric Surgery in Children and Adolescents Amid the Rise of GLP-1 Receptor Agonists: A Narrative Review

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Abstract

Background. Pediatric obesity is a chronic, progressive disease associated with metabolic, cardiovascular, orthopedic and psychosocial complications. Metabolic and bariatric surgery can provide substantial and durable weight reduction in adolescents with severe obesity, but it is invasive and requires lifelong follow-up. The growing availability of glucagon-like peptide-1 receptor agonists may influence the role of surgery.

Aim. This narrative review summarizes evidence on the indications, outcomes and complications of bariatric surgery in children and adolescents and discusses its evolving role in the era of GLP-1 receptor agonist therapy.

Material and methods. PubMed, Scopus and Web of Science were searched for articles published between 2016 and 2026. Landmark studies and guidelines published before 2016 were also included. The search covered pediatric obesity, adolescent bariatric surgery, sleeve gastrectomy, Roux-en-Y gastric bypass, complications, type 2 diabetes, liraglutide, semaglutide and GLP-1 receptor agonists.

Results. Metabolic and bariatric surgery provides the most established long-term evidence for substantial weight loss and improvement of obesity-related complications in adolescents with severe obesity. Liraglutide and semaglutide produce clinically meaningful short-term BMI reductions and may serve as alternatives or components of multimodal care. Surgery is also associated with improved mobility, physical function, musculoskeletal pain and health-related quality of life, whereas evidence on objectively measured fitness, participation in sport and routine perioperative use of GLP-1 receptor agonists remains limited.

Conclusions. GLP-1 receptor agonists do not eliminate the need for metabolic and bariatric surgery in pediatric patients but may change treatment sequencing and shared decision-making. Care should be individualized, multidisciplinary and guided by effectiveness, psychological well-being and long-term safety.

Key words: pediatric obesity, adolescent obesity, bariatric surgery, metabolic surgery, GLP-1 receptor agonists, semaglutide, liraglutide, sleeve gastrectomy, type 2 diabetes

1. Introduction

Pediatric obesity is one of the major public health challenges of recent decades. It is now recognized as a chronic, relapsing and multifactorial disease influenced by genetic, biological, environmental and psychosocial factors. In Europe, a meta-analysis of measured data from 1999 to 2016 found that approximately one in five children had overweight or obesity. Severe pediatric obesity is of particular concern because it frequently persists into adulthood and is associated with early metabolic complications (1,2).

The clinical consequences of obesity in childhood and adolescence include insulin resistance, type 2 diabetes, dyslipidemia, hypertension, obstructive sleep apnea, metabolic dysfunction-associated steatotic liver disease, orthopedic disorders and impaired quality of life. Adolescents may also experience weight stigma, low self-esteem, depressive symptoms and disordered eating. Because these complications can develop before adulthood, early and multidisciplinary treatment is preferable to prolonged observation alone (2-6).

Lifestyle modification, nutritional counseling and behavioral treatment remain the foundation of pediatric obesity care, but they are often insufficient in adolescents with severe obesity and established comorbidities. In this population, metabolic and bariatric surgery is an evidence-based option. Current guidelines recommend referral for surgical evaluation in adolescents with class II obesity and clinically significant comorbidities or class III obesity after multidisciplinary assessment. Sleeve gastrectomy and Roux-en-Y gastric bypass are the principal operations, whereas endoscopic approaches have a more limited and evolving pediatric role (3,7-9).

Metabolic and bariatric surgery can produce substantial and durable weight loss and improve or remit obesity-related complications. However, it is invasive and carries perioperative risks as well as long-term concerns, including gastroesophageal reflux, micronutrient deficiencies, effects on bone health, lifelong supplementation and psychological adaptation. These considerations are particularly relevant during ongoing physical and psychosocial development (10-15).

The therapeutic landscape has changed with the introduction of modern anti-obesity medications, particularly GLP-1 receptor agonists. In the European Union, liraglutide is authorized for weight management in children aged 6 to <12 years with obesity and body weight of at least 45 kg, as well as in adolescents aged 12 years and older who meet product-specific criteria. Semaglutide is authorized for adolescents aged 12 years and older with obesity and body weight above 60 kg. Randomized trials have demonstrated clinically meaningful BMI reductions when these agents are combined with lifestyle intervention. Use of prescription anti-obesity medications among adolescents has also increased in routine clinical practice in the United States. The STEP TEENS trial reported a substantially greater mean BMI reduction with once-weekly semaglutide than with placebo (2,16-20).

Several questions remain unresolved. Pediatric trials of GLP-1 receptor agonists have substantially shorter follow-up than adolescent surgical cohorts, and no large randomized study has directly compared modern pharmacotherapy with sleeve gastrectomy or Roux-en-Y gastric bypass. Treatment duration, adherence, cost, adverse effects and weight recurrence after discontinuation may influence the long-term role of pharmacotherapy. GLP-1 receptor agonists should therefore be viewed as additional tools that may delay, complement or, in selected patients, provide an alternative to surgery rather than as universal replacements for surgical treatment (9-12,16,17,21).

The aim of this narrative review was to summarize current evidence regarding the indications, methods, effectiveness and complications of metabolic and bariatric surgery in children and adolescents and to discuss its evolving role in the era of GLP-1 receptor agonist therapy.

2. Materials and Methods

A structured literature search was conducted in PubMed/MEDLINE, Scopus and Web of Science to identify publications addressing pediatric obesity, metabolic and bariatric surgery in children and adolescents, surgical outcomes and complications, and treatment with GLP-1 receptor agonists. The search covered publications issued between 1 January 2016 and 22 June 2026, with selected landmark studies and clinical guidelines published before 2016 included when they were considered essential to the clinical or conceptual framework of the review. The

final search update was performed on 22 June 2026. Search terms were combined using the Boolean operators AND and OR and included: (“pediatric obesity” OR “childhood obesity” OR “adolescent obesity”) AND (“bariatric surgery” OR “metabolic surgery” OR “sleeve gastrectomy” OR “Roux-en-Y gastric bypass” OR “endoscopic sleeve gastroplasty” OR “intragastric balloon”), as well as (“pediatric obesity” OR “adolescent obesity”) AND (“GLP-1 receptor agonist” OR “liraglutide” OR “semaglutide” OR “anti-obesity medication”). Additional searches included combinations of these terms with “type 2 diabetes”, “weight loss”, “comorbidities”, “complications”, “safety”, “quality of life” and “long-term outcomes”. Reference lists of relevant reviews, guidelines and key clinical studies were also screened to identify additional publications.

Titles and abstracts were screened for relevance, followed by full-text assessment of potentially eligible publications. Original research articles, randomized controlled trials, cohort studies, systematic reviews, meta-analyses and clinical guidelines were considered eligible when they included patients younger than 18 years or provided adolescent-specific data on indications, effectiveness, safety or long-term outcomes of surgery or GLP-1 receptor agonist therapy. Conference abstracts, opinion articles without sufficient methodological detail, publications without accessible full text and studies that did not provide pediatric- or adolescent-specific findings were excluded. English-language scientific publications were primarily included; selected official regulatory and governmental documents published in other languages were also considered when necessary to describe European authorization, accessibility and reimbursement of GLP-1 receptor agonists. These included documents issued by the European Medicines Agency and the Polish Ministry of Health. A total of 39 sources were included in the final narrative synthesis. Because the review was not conducted as a systematic review and no prospective screening log was maintained, the exact number of records initially retrieved from each database could not be reliably reconstructed. No formal risk-of-bias assessment or meta-analysis was performed, and the selected evidence was synthesized thematically.

3. Research results

3.1. Indications for bariatric surgery in children and adolescents

Metabolic and bariatric surgery should be considered for adolescents with severe obesity when the expected benefits outweigh the risks and treatment can be provided by an experienced multidisciplinary team. Current recommendations no longer regard surgery solely as a last resort after years of unsuccessful treatment, but as an evidence-based therapy for selected patients with severe obesity and clinically significant complications (3,7,8,22).

According to the American Academy of Pediatrics and ASMBS guidance, adolescents with class II obesity (BMI at least 120% of the 95th percentile for age and sex or BMI at least 35 kg/m2) and a clinically significant comorbidity should be considered for surgical evaluation. Adolescents with class III obesity (BMI at least 140% of the 95th percentile or BMI at least 40 kg/m2) may be considered even without a major comorbidity, provided that they meet clinical, psychological and social criteria for long-term care (3,7,8,22).

Comorbidities supporting surgical referral include type 2 diabetes, moderate-to-severe obstructive sleep apnea, hypertension, dyslipidemia, metabolic dysfunction-associated steatotic liver disease, orthopedic complications, impaired mobility and markedly reduced health-related quality of life. Type 2 diabetes is particularly important because youth-onset disease may progress rapidly. Teen-LABS data demonstrate durable improvement in cardiometabolic risk factors and sustained diabetes remission in a substantial proportion of operated adolescents (3,10-12,22).

Previous response to conservative treatment remains relevant, but prolonged exposure to ineffective therapy should not be required before referral. Lifestyle, nutritional and family-

based behavioral interventions remain foundational, yet they often do not produce sufficient or durable weight loss in severe adolescent obesity. Current guidelines therefore support timely referral to specialized centers when accepted surgical criteria are met (3,7,8,22).

Age is important but should not be used as an isolated eligibility criterion. The American Academy of Pediatrics recommends referral for surgical evaluation in adolescents aged 13 years and older with severe obesity. Chronological age, pubertal stage or incomplete linear growth should not automatically exclude a patient; the assessment should instead consider developmental understanding, psychological readiness and the capacity to participate in lifelong follow-up (3,7,22).

A multidisciplinary assessment is essential before surgery. The team should include a pediatric or adolescent medicine specialist, bariatric surgeon, dietitian and psychologist or psychiatrist, with additional specialists involved when indicated. Evaluation should confirm obesity severity, identify comorbidities, assess family support and treatment expectations, and address uncontrolled conditions that could compromise postoperative safety or adherence (3,7,22).

The availability of GLP-1 receptor agonists has changed treatment sequencing but has not eliminated the role of surgery. In the European Union, liraglutide may be considered from 6 years of age in children with obesity who meet product-specific criteria, whereas semaglutide is authorized for adolescents aged 12 years and older. These medications may provide an alternative for selected patients or be integrated into multimodal care. They should not, however, become an obligatory step before surgical referral when accepted criteria are already met and severe or progressive comorbidities are present (2,3,7,9,16,17,19,20).

3.2. Surgical and endoscopic treatment methods

Metabolic and bariatric surgery provides the most established long-term evidence for substantial weight loss in adolescents with severe obesity. Its effects reflect reduced gastric capacity, altered nutrient flow and changes in appetite-regulating and metabolic pathways. Procedure selection should be individualized according to clinical characteristics, comorbidities, expected long-term outcomes and center expertise (2,7,9,22).

Sleeve gastrectomy

Laparoscopic sleeve gastrectomy (LSG) is the most frequently performed bariatric procedure in adolescents. Most of the greater gastric curvature and fundus are removed, creating a tubular stomach. In addition to reducing gastric capacity, LSG decreases fasting ghrelin concentrations and increases postprandial GLP-1 and peptide YY responses, contributing to satiety and metabolic improvement (7,22,23).

LSG produces substantial and durable weight loss and improves multiple obesity-related conditions. Compared with Roux-en-Y gastric bypass, it is technically less complex, preserves intestinal continuity and generally carries a lower risk of long-term micronutrient deficiencies. Its principal procedure-specific concern is the development or worsening of gastroesophageal reflux disease, which requires long-term surveillance (7,10-13,22).

Roux-en-Y gastric bypass

Roux-en-Y gastric bypass (RYGB) creates a small gastric pouch that is connected to the jejunum, bypassing the duodenum and part of the proximal small intestine. Weight loss and metabolic effects result from restriction, altered nutrient flow and hormonal changes that improve insulin sensitivity and glucose regulation (7,11,22).

RYGB remains highly effective but is used less frequently in adolescents following the widespread adoption of LSG. It may be preferred in selected patients, particularly those with severe gastroesophageal reflux disease or when sleeve gastrectomy is considered unsuitable.

Because RYGB has a greater effect on nutrient absorption, lifelong supplementation and biochemical monitoring are essential (7,11,13,22).

Endoscopic bariatric therapies

Endoscopic bariatric therapies, particularly endoscopic sleeve gastroplasty (ESG) and intragastric balloons, have emerged as less invasive options. ESG reduces gastric volume using full-thickness endoscopic sutures without gastric resection, whereas intragastric balloons temporarily occupy gastric space to promote earlier satiety. Recent adolescent studies have reported weight loss with swallowable intragastric balloons, while device-related complications have also been described (24-26).

Both methods can produce clinically meaningful weight loss in adults, but pediatric evidence remains limited and is based mainly on observational cohorts. Early findings for ESG are encouraging, yet long-term durability, metabolic outcomes and comparative safety are not established to the same degree as for LSG and RYGB. Endoscopic therapies should therefore be regarded as selected or emerging options in adolescents and used in experienced multidisciplinary centers or research settings (3,7,24-26).

Selection of the optimal procedure

Selection of the optimal procedure should extend beyond expected weight loss. Obesity severity, comorbidities, gastroesophageal reflux, nutritional status, psychological readiness, family support and the ability to maintain long-term follow-up should be considered through shared decision-making with the patient and caregivers (3,7,8,22).

GLP-1 receptor agonists may be integrated before or after surgery in selected patients, but pediatric evidence on optimal timing and long-term outcomes remains limited. Preoperative therapy may improve weight or glycemic control, although it has not been shown consistently to reduce operative risk or improve postoperative weight loss. Postoperative use for persistent obesity or weight recurrence is promising but is supported mainly by small, non-randomized studies (9,27-31).

3.3. Treatment effectiveness measured by weight loss and metabolic outcomes

The goals of metabolic and bariatric surgery extend beyond weight loss to include remission or improvement of comorbidities, better quality of life and reduction of long-term cardiometabolic risk (2,10-13).

Prospective Teen-LABS data demonstrate substantial and durable weight loss. At three years, mean body weight decreased by 27% in the overall cohort, including 26% after LSG and 28% after RYGB. At ten years, mean BMI remained approximately 19.2% below baseline after LSG and 20.6% below baseline after RYGB, confirming durable benefit while also showing that outcomes vary over time and between individuals (10,12).

Surgery also produces important metabolic benefits. In Teen-LABS, type 2 diabetes, elevated blood pressure and dyslipidemia frequently improved or remitted, although rates varied according to procedure, outcome definition and follow-up duration. These effects are particularly relevant because youth-onset type 2 diabetes may progress rapidly and cause early complications (10-12).

Obstructive sleep apnea and health-related quality of life may also improve after surgery. Durable benefit nevertheless depends on continued follow-up, nutritional supplementation and long-term support for behavioral and psychological needs (10,13,32).

GLP-1 receptor agonists have expanded non-surgical treatment options. In randomized trials, liraglutide and semaglutide produced greater BMI reductions than lifestyle intervention with placebo. Liraglutide produced an estimated treatment difference in BMI of -4.64 percentage points at 56 weeks, whereas semaglutide produced a mean BMI change of -16.1%

at 68 weeks. These findings should not be interpreted as direct comparisons with surgery because the populations, outcomes and follow-up periods differed substantially (16,17).

Long-term durability after medication discontinuation remains uncertain in adolescents. Adult extension data show substantial weight recurrence after semaglutide withdrawal, but these findings cannot be assumed to apply fully to pediatric patients. In contrast, surgical cohorts provide follow-up extending to ten years, although surgery also requires lifelong surveillance for nutritional and procedure-specific complications (10-13,21).

Pharmacotherapy and surgery should therefore be considered complementary rather than competing strategies. GLP-1 receptor agonists may provide an alternative for selected adolescents and may eventually support treatment before or after surgery, but current pediatric evidence is insufficient to define a routine sequence or combination regimen (9,27-31).

Table 1. Weight and metabolic outcomes reported in major adolescent studies of bariatric surgery and GLP-1 receptor agonists

Outcome	Sleeve gastrectomy (LSG)	Roux-en-Y gastric bypass (RYGB)	GLP-1 receptor agonists
Weight or BMI reduction	Mean body-weight reduction: approximately 26% at 3 years; mean BMI reduction: approximately 19.2% at 10 years.	Mean body-weight reduction: approximately 28% at 3 years and 26% at 5 years; mean BMI reduction: approximately 20.6% at 10 years.	Liraglutide: estimated BMI difference versus placebo of -4.64 percentage points at 56 weeks; semaglutide: mean BMI change of -16.1% at 68 weeks.
Type 2 diabetes remission	Procedure-specific remission cannot be reliably determined from the cited pooled Teen-LABS analyses.	86% remission at 5 years in adolescents undergoing RYGB.	Not established as a remission outcome in the major adolescent obesity trials.
Overall bariatric surgery cohort: type 2 diabetes remission	95% at 3 years and 55% at 10 years in the pooled metabolic and bariatric surgery cohort. Pooled metabolic and bariatric surgery cohort: 95% at 3 years and 55% at 10 years.		Improvements in glycemic measures may occur, but direct remission comparisons with surgery are unavailable.
Hypertension remission	Procedure-specific long-term estimates are not consistently reported in the cited studies.	68% at 5 years after RYGB.	Hypertension remission was not a primary established outcome in the major adolescent obesity trials.
Overall bariatric surgery cohort: hypertension remission	74% at 3 years and 57% at 10 years in the pooled surgical cohort. Pooled surgical cohort: 74% at 3 years and 57% at 10 years.		Changes in blood pressure may occur, but remission rates have not been established.

Outcome	Sleeve gastrectomy (LSG)	Roux-en-Y gastric bypass (RYGB)	GLP-1 receptor agonists
Nutritional risk	Micronutrient deficiencies may occur; low ferritin was reported in approximately 45% at 5 years.	Greater nutritional risk; low ferritin was reported in approximately 71% at 5 years.	No surgery-related malabsorption; nutritional intake and adequacy should nevertheless be monitored during prolonged treatment.

Abbreviations: BMI, body mass index; GLP-1, glucagon-like peptide-1; LSG, laparoscopic sleeve gastrectomy; RYGB, Roux-en-Y gastric bypass.
Interpretation note: Outcomes should not be compared directly without caution because the cited studies differed in treatment duration, follow-up period, patient characteristics and outcome definitions. Surgical studies report both percentage body-weight change and percentage BMI change, whereas pharmacological trials primarily report change in BMI over approximately one year.
Sources: references 10-13,16,17.

3.4. Patient-centered outcomes: mobility, physical activity, musculoskeletal pain and quality of life

Weight reduction may provide clinically meaningful benefits beyond metabolic control by improving mobility, physical function, musculoskeletal symptoms and health-related quality of life. In Teen-LABS, adolescents completed a standardized 400-m walk test more rapidly, had lower resting and post-exercise heart rates, and reported fewer walking-related musculoskeletal pain concerns after surgery, with these improvements maintained for up to two years (33).

A separate three-year analysis found an approximately 40% reduction in the prevalence of musculoskeletal and lower-extremity pain, together with sustained improvements in self-reported physical function, physical comfort and health-related quality of life (34). These changes may reduce important barriers to recreational physical activity and sport, although participation in organized sport was not directly measured. Semaglutide also improved weight-related quality of life in the STEP TEENS trial, particularly physical comfort; however, evidence regarding objectively measured mobility, cardiorespiratory fitness and long-term physical activity after GLP-1 receptor agonist therapy remains limited (17).

3.5. Possible complications

Metabolic and bariatric surgery is generally safe when performed in experienced pediatric centers, but it remains invasive and is associated with short- and long-term risks. Careful selection, multidisciplinary preparation and lifelong follow-up are required to maximize benefit and identify complications early (7,15,22).

Early postoperative complications

Early complications within 30 days may include bleeding, anastomotic or staple-line leak, surgical site infection, venous thromboembolism, bowel obstruction and anesthesia-related events. Teen-LABS demonstrated a favorable short-term safety profile, although some patients required early reintervention or additional care (15).

Long-term nutritional complications

Micronutrient deficiencies are among the most important long-term concerns. Reduced intake and altered gastrointestinal anatomy may lead to deficiencies of iron, vitamin B12, folate, calcium, vitamin D and other nutrients. The burden is generally greater after RYGB than after LSG, but clinically relevant deficiencies occur after both procedures. Lifelong supplementation and regular biochemical monitoring are therefore essential (13).

Bone health and growth

Bone health requires particular attention because surgery occurs before or near the attainment of peak bone mass. Rapid weight loss, changes in mechanical loading and altered calcium and vitamin D metabolism may reduce bone mineral density. Linear growth is not generally impaired in appropriately selected adolescents, but long-term skeletal monitoring remains advisable (14).

Gastrointestinal complications

Procedure-specific gastrointestinal complications should influence treatment selection. Gastroesophageal reflux may develop or worsen after LSG. RYGB often improves reflux but carries risks of marginal ulceration, dumping syndrome, internal hernia and small-bowel obstruction (2,7,13,22).

Psychological considerations

Many adolescents report improved self-esteem and quality of life after surgery, but psychological outcomes are not uniformly positive. Depression, anxiety, body-image concerns, disordered eating, suicidal thoughts or difficulties adapting to rapid physical change may persist or emerge. Psychological assessment and support should therefore continue after surgery rather than end at qualification (32,35).

Comparison with pharmacotherapy

GLP-1 receptor agonists do not carry surgical or malabsorptive risks but have a distinct safety profile. Gastrointestinal adverse effects, including nausea, vomiting, diarrhea, constipation and abdominal pain, are common and may lead to treatment discontinuation. Rare safety concerns include gallbladder disease and pancreatitis. Their effects generally depend on continued treatment, and long-term pediatric safety data remain limited (2,16,17).

For appropriately selected adolescents with severe obesity, the expected benefits of surgery generally outweigh the risks of untreated disease and the procedure itself. This balance depends on structured lifelong follow-up that addresses nutrition, bone health, psychological well-being and procedure-specific complications (3,7,13-15).

3.6. Ethical and psychological aspects

Treatment decisions in pediatric obesity should address psychological well-being, quality of life, family context and patient preferences in addition to weight and metabolic outcomes. Children and adolescents with obesity frequently experience stigma, bullying, social isolation and low self-esteem, which may worsen mental health and reduce engagement with care. Internalized weight bias, guilt and shame may further impair psychosocial functioning. Non-stigmatizing language and routine screening for psychological difficulties are therefore essential (3-6,36).

Psychological evaluation before surgery should identify support needs rather than automatically exclude adolescents with emotional difficulties. Relevant concerns include depression, anxiety, binge-eating or loss-of-control eating, suicidal thoughts, unrealistic expectations, poor family support and barriers to long-term adherence. Patients and caregivers should understand the need for lifelong follow-up, dietary change, supplementation and psychological monitoring (7,32,35).

Age influences treatment eligibility but should not replace individualized assessment. In the European Union, liraglutide is authorized from 6 years of age in children with obesity who meet product-specific criteria, whereas semaglutide is authorized for adolescents aged 12 years and older. The AAP recommends referral for bariatric surgery evaluation from 13 years of age in adolescents with severe obesity. In younger children, intensive family-based behavioral treatment remains central, and pharmacotherapy or surgery requires specialist, multidisciplinary assessment (2,3,16,17,19,20,37).

The availability of GLP-1 receptor agonists adds an ethical dimension to treatment selection. Medication is less invasive but may require chronic use, regular monitoring and sustained access. Surgery may provide greater and more durable weight loss in selected patients but is anatomically irreversible and requires lifelong surveillance. Shared decision-making should involve the patient, caregivers and the multidisciplinary team (2,3,9,32).

Ethical care requires treatment intensity to be matched to medical risk while respecting the adolescent's developmental stage, autonomy and capacity to participate in decisions. Psychological readiness, family support, realistic expectations and access to long-term follow-up are more informative than a simple age threshold (3,7,8,32).

3.7. Controversies regarding long-term health risks

Despite the established effectiveness of adolescent metabolic and bariatric surgery, uncertainty remains about very long-term outcomes. Some patients experience partial weight recurrence, and remission of comorbidities may diminish over time. Surgery should therefore be understood as a durable treatment for a chronic disease rather than a definitive cure (10-12).

Nutritional and skeletal outcomes remain central concerns. Lifelong supplementation is required after surgery, particularly after RYGB, and reduced bone mineral density has been reported during long-term follow-up. The clinical significance of these changes across adulthood requires further study (13,14).

GLP-1 receptor agonists introduce different long-term uncertainties. Pediatric trials demonstrate clinically meaningful short-term efficacy, but the optimal duration of therapy, safety during prolonged use and maintenance of benefit after discontinuation remain unclear. Adult withdrawal data suggest substantial weight recurrence, but direct pediatric evidence is limited (16,17,21).

No randomized pediatric trial has directly compared modern GLP-1 receptor agonists with LSG or RYGB. Consequently, conclusions about superiority, treatment sequencing or combination therapy are based on indirect comparisons and early observational evidence. Long-term studies should evaluate weight, comorbidity remission, growth, bone health, psychological outcomes, adherence, access and cost-effectiveness (2,9).

These uncertainties support a flexible, long-term model of care in which treatment is adjusted to disease severity, clinical response and patient preferences rather than a fixed hierarchy of lifestyle therapy, medication and surgery (2,3,7,9).

3.8. Future of bariatric surgery in the GLP-1 era

The introduction of GLP-1 receptor agonists has expanded the therapeutic pathway for pediatric obesity, but current evidence does not support treating pharmacotherapy and surgery as directly interchangeable. Future care is more likely to use lifestyle intervention, medication and surgery as complementary components selected according to obesity severity, comorbidities, response to previous treatment and patient circumstances (3,7-9).

3.9. Clinical Decision-Making Between GLP-1 Receptor Agonists and Bariatric Surgery in Europe

Published national and pan-European data do not currently permit a reliable estimate of how often clinicians choose GLP-1 receptor agonist therapy instead of metabolic and bariatric surgery after an inadequate response to lifestyle treatment. In clinical practice, these options are usually considered within a staged, multidisciplinary pathway rather than as mutually exclusive alternatives. GLP-1 receptor agonists may be introduced before or alongside surgical assessment because they are non-invasive, reversible and authorized in the European Union for selected pediatric populations. Metabolic and bariatric surgery remains an important option for adolescents with severe obesity, progressive or clinically significant comorbidities, or an inadequate response or intolerance to non-surgical treatment. The choice is individualized according to obesity severity, anticipated benefit, psychological readiness, family preferences, access to specialist follow-up, treatment cost and reimbursement. Access to pharmacotherapy varies across Europe, and publicly available Polish data do not distinguish prescriptions for pediatric obesity from other indications or allow direct comparison with referrals for bariatric surgery (19,20,38,39).

GLP-1 receptor agonists may change the timing of referral and provide an alternative for some adolescents, but they should not be an obligatory prerequisite for surgery. Pediatric medication trials cover approximately one year, whereas surgical cohorts extend to five and ten years, and no randomized pediatric trial directly compares the two strategies (10-12,16,17).

Metabolic and bariatric surgery is likely to remain important for adolescents with severe obesity and progressive metabolic or mechanical complications. Ten-year Teen-LABS findings support durable weight loss and persistent improvement of type 2 diabetes, hypertension and dyslipidemia in many patients (11,12).

The optimal use of GLP-1 receptor agonists around surgery remains uncertain. A recent retrospective multicenter study did not show a clear overall advantage of preoperative anti-obesity medication for total weight loss through 12 months after surgery. Early pediatric studies of postoperative liraglutide or reintroduction of anti-obesity medication suggest potential benefit for persistent obesity or weight recurrence, but the evidence is small and non-randomized (27,28,31).

Future research should identify which adolescents are most likely to respond to medication alone, which benefit from earlier surgery and which may require combined treatment. Outcomes should include comorbidity remission, growth, pubertal development, bone health, psychological well-being, quality of life, adherence and cost-effectiveness (2,9).

The GLP-1 era is therefore unlikely to end pediatric bariatric surgery. Instead, it may transform surgery from an isolated intervention into one component of adaptive, long-term obesity care in which treatments are combined or modified according to clinical response and patient preference (9,27-31).

4. Discussion

The findings of this narrative review indicate that GLP-1 receptor agonists have expanded the treatment options for pediatric obesity without eliminating the role of metabolic and bariatric surgery. Rather than competing as mutually exclusive therapies, lifestyle intervention, pharmacotherapy and surgery should form a graduated and adaptable treatment pathway. The appropriate level of intervention should reflect obesity severity, associated complications, previous treatment response and the individual circumstances of the patient and family (3,7-9).

Metabolic and bariatric surgery currently has the most established long-term evidence for adolescents with severe obesity. Teen-LABS demonstrated substantial and sustained weight reduction together with meaningful improvement in metabolic comorbidities and quality of life. Although outcomes differ between patients and some degree of weight recurrence may occur, the available follow-up supports surgery as a durable component of chronic disease management rather than a definitive cure (10,12).

This durability may be particularly important in adolescents with youth-onset type 2 diabetes, in whom disease progression and the development of vascular or renal complications may occur early. The favorable metabolic outcomes observed after RYGB support timely consideration of surgery in appropriately selected patients rather than prolonged postponement of effective treatment. Nevertheless, remission rates should always be interpreted in relation to the procedure performed, the definition of remission and the duration of observation (11).

GLP-1 receptor agonists have narrowed the therapeutic gap between behavioral treatment and surgery. Liraglutide and semaglutide provide clinically meaningful BMI reduction without anatomical alteration and may allow some adolescents to avoid or delay an operation. However, the absence of randomized head-to-head pediatric trials means that their effectiveness cannot be directly equated with that of LSG or RYGB. Differences in baseline obesity severity, outcome measures and follow-up duration further limit indirect comparisons (2,16,17).

The duration of benefit remains one of the most important uncertainties surrounding pharmacotherapy. Surgical cohorts provide several years of follow-up, whereas pivotal pediatric GLP-1 trials have generally lasted approximately one year. Weight recurrence after semaglutide withdrawal in adults raises concern that treatment may need to be continued long term, although these findings cannot yet be directly extrapolated to adolescents (10-12,21).

The choice between treatment options should therefore be based on their different risk profiles rather than on an assumption that one approach is inherently safe and the other inherently hazardous. Surgery requires perioperative assessment, lifelong nutritional surveillance and monitoring for procedure-specific complications, including micronutrient deficiencies and changes in bone health. GLP-1 receptor agonists avoid anatomical modification but may be limited by gastrointestinal adverse effects, treatment discontinuation, adherence, cost and unequal access. These risks must also be weighed against the consequences of leaving severe obesity insufficiently treated (2,13-17).

Procedure selection should likewise reflect the clinical needs of the individual patient. LSG is the most frequently used adolescent operation but may aggravate gastroesophageal reflux, whereas RYGB may be more appropriate in selected patients with severe reflux despite its greater nutritional burden. Endoscopic procedures are less invasive and potentially attractive to patients and families, but the available pediatric evidence is based mainly on observational studies and does not yet demonstrate comparable long-term durability (7,13,22,24-26).

Psychological and patient-centered outcomes should remain central to treatment planning. Weight reduction may improve mobility, physical function, self-esteem and quality of life, and may reduce musculoskeletal pain, but it does not necessarily resolve depression, anxiety, disordered eating, body-image concerns or weight-related stigma. Psychological assessment should therefore identify individual support needs and readiness for long-term treatment rather than serve primarily as an obstacle to pharmacological or surgical care (4-6,32-36).

A combined treatment model may become increasingly relevant. GLP-1 receptor agonists may be used before surgery, after surgery in patients with persistent obesity or weight recurrence, or as an alternative in patients who respond adequately to medication. However, the current pediatric evidence is based on small, non-randomized studies and is insufficient to establish routine perioperative treatment protocols. Preoperative pharmacotherapy has also not consistently improved early postoperative outcomes (27,28,31).

For clinicians, the principal implication is that referral for surgical assessment should not be delayed solely to require an unsuccessful trial of GLP-1 therapy. BMI and comorbidities remain important, but treatment decisions should additionally account for disease progression, developmental readiness, family support, psychological factors, previous response to treatment and the feasibility of long-term follow-up. In European and Polish practice, the theoretical effectiveness of a treatment must also be considered alongside its actual availability, affordability and continuity of care (3,7-9).

This review has several limitations. Its narrative design did not include a formal risk-of-bias assessment or quantitative synthesis, and the available evidence is heterogeneous. Surgical outcomes are derived primarily from prospective cohorts, whereas pharmacological efficacy is supported by shorter randomized trials. Consequently, direct comparison remains uncertain. Important evidence gaps include outcomes in younger children, long-term skeletal and reproductive health, optimal treatment sequencing, combined pharmacological and surgical strategies, real-world access and cost-effectiveness.

Overall, the GLP-1 era is more likely to reshape than replace adolescent metabolic and bariatric surgery. Pharmacotherapy may reduce, postpone or complement surgery in selected patients, whereas surgery will remain particularly relevant for severe obesity, advanced comorbidities and inadequate response to non-surgical treatment. The most appropriate future model is therefore an adaptive, multidisciplinary pathway in which treatment is intensified, combined or modified according to clinical response, safety, accessibility and patient preferences (3,7-12,16,17).

5. Conclusions

Metabolic and bariatric surgery remains an important and effective option for carefully selected adolescents with severe obesity, particularly when clinically significant metabolic or mechanical complications are present. GLP-1 receptor agonists have expanded therapeutic possibilities and may reduce or delay the need for surgery in some patients, but current evidence does not support replacing surgery in all cases. Pharmacotherapy and surgery should be regarded as complementary components of individualized care. Further long-term studies are required to clarify their durability, safety, optimal sequencing and cost-effectiveness in pediatric populations. Future treatment should be multidisciplinary and guided by medical risk, treatment response, psychological readiness, quality of life and patient preferences.

Disclosure

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