International Journal of Contemporary Pediatrics
Shankar Babu SH et al. Int J Contemp Pediatr. 2024 Oct;11(10):1499-1505
http://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291

DOI: https://dx.doi.org/10.18203/2349-3291.ijcp20242754

Review Article

What are the realms of pediatric weight reduction surgery and what is its influence on digestive wellbeing?

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Received: 22 July 2024
Accepted: 16 August 2024

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ABSTRACT

The escalating prevalence of paediatric obesity poses profound health challenges, prompting a quest to foster effective weight loss strategies. Surgical interventions have emerged as pivotal tools to do so, with the most common of these being laparoscopic gastrectomy (LSG), Roux-en-Y gastric bypass (RYGB), and adjustable gastric banding (AGB). This systematic review meticulously examines these surgical modalities alongside their outcomes in the short and long term and also, touches upon plausible alternatives to surgery in the event that surgery is contraindicated. Electronic search was conducted in PubMed, Science Direct and Cochrane Library and we sought out studies that specifically focused on pediatric patients. This yielded 30 sources, which were further shortlisted to 24 that were able to provide useful information suitable for this systematic review. Our findings suggest that there is ongoing debate on which specific surgical intervention prevails and positive and negative outcomes, alike, are associated with them all. We believe that it is agreeable that inspite of its shortcomings, bariatric surgical methods are able to offer enduring solutions and thus optimises health outcomes of pediatric patients, especially those with severe obesity.

Keywords: Pediatric laparoscopic sleeve gastrectomy, Gastrectomy, Roux-En-Y, Gastric anastomosis, AGB, Gastric banding

INTRODUCTION

Obesity in the pediatric population is an immense concern due to the mortality risk it deals to a vulnerable population. The World Health Organisation (WHO) defines the pediatric population as children between the ages of 5-19 years and are classified as obese when with body mass index (BMI)-for-age and sex are above the 97th percentile.[1] Surgical interventions are a tremendous asset to combat obesity due to their robust capacity to suppress appetite and foster weight loss. This systematic review discusses the options within pediatric weight reduction surgery and its consequent impact on gut health.

AGB, shown in Figure 1, was a method introduced by Lubomyr Kuzmak. It exists as two band methods, namely the refined "LAP-band AP version" and "the realize" band.[2] The laparoscopic procedure involves a 5-port technique, with omental movement for visibility, a small incision on the left side of the gastroesophageal junction. Band insertion through a 15-mm trocar avoids harm, with the LAP-band pulled through the posterior esophagogastric tunnel.[3] While the LAP-band tubing tag is fed through the locking mechanism, the realize band is closed using a dissector through the buckle opening. Plicating of the fundus and cardia below the band is necessary in the anterior region, followed by gastro-gastric suturing over the band using permanent suture material. Though effective, this procedure has been abandoned in both children and adults due to its frequent need for revision surgery.[4,5]

Sleeve LSG, shown in Figure 2, removes a large portion of the stomach, leaving a narrow sleeve shape remnant. To do so, a five or six trocar setting may be used. It

involves retraction of the left lobe of the liver and careful dissection along the greater curve, while being mindful of the left gastric artery at this site. The stomach division starts 4cm proximal to the pylorus, and a bougie is used to guide stapling.[3]

Laparoscopic restrictive-malabsorptive RYGB, shown in Figure 3, a minimally invasive procedure, was pioneered in 1994 by César Roux and Charles Depage. The procedure involves trocar insertion above the umbilicus, followed by dissection, pouch formation, and creation of the roux and biliopancreatic limbs. The roux limb can be positioned in either an antecolic-ante gastric or retrocolic-retrogastric orientation, with reinforced staple lines to minimize leakage risk. Typically lasting 50-90 minutes, the surgery necessitates a hospital stay of two to four days, including postoperative leak testing for patient safety.[1] Side-to-side anastomoses, such as gastrojejunostomy and jejunojejunostomy, mitigate risks and facilitate proper absorption and digestion of nutrients.[6]

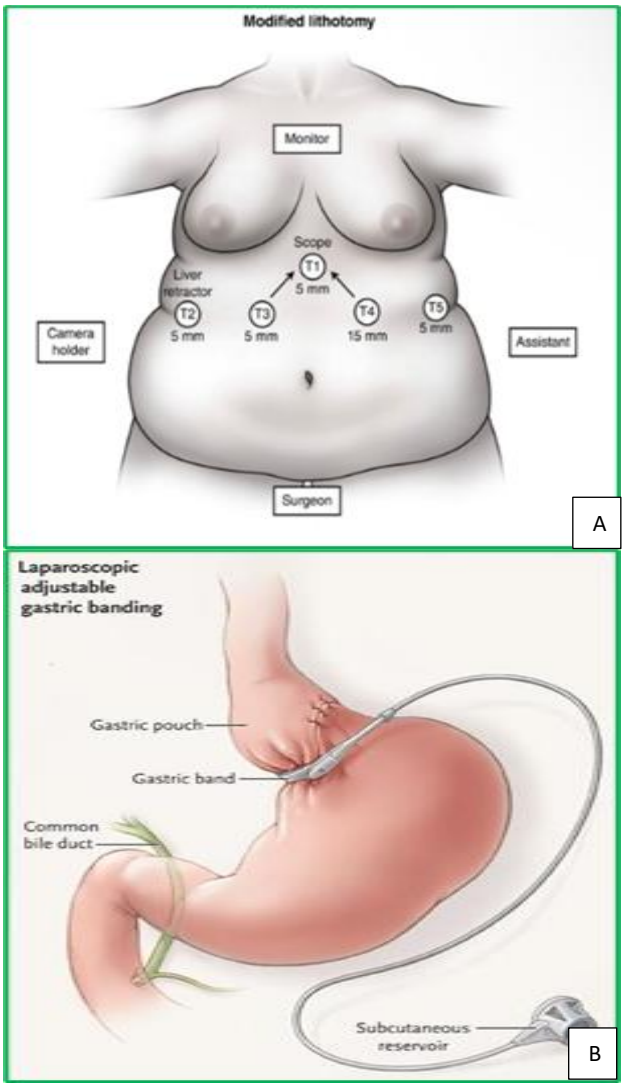

Figure 1 (A and B): AGB.

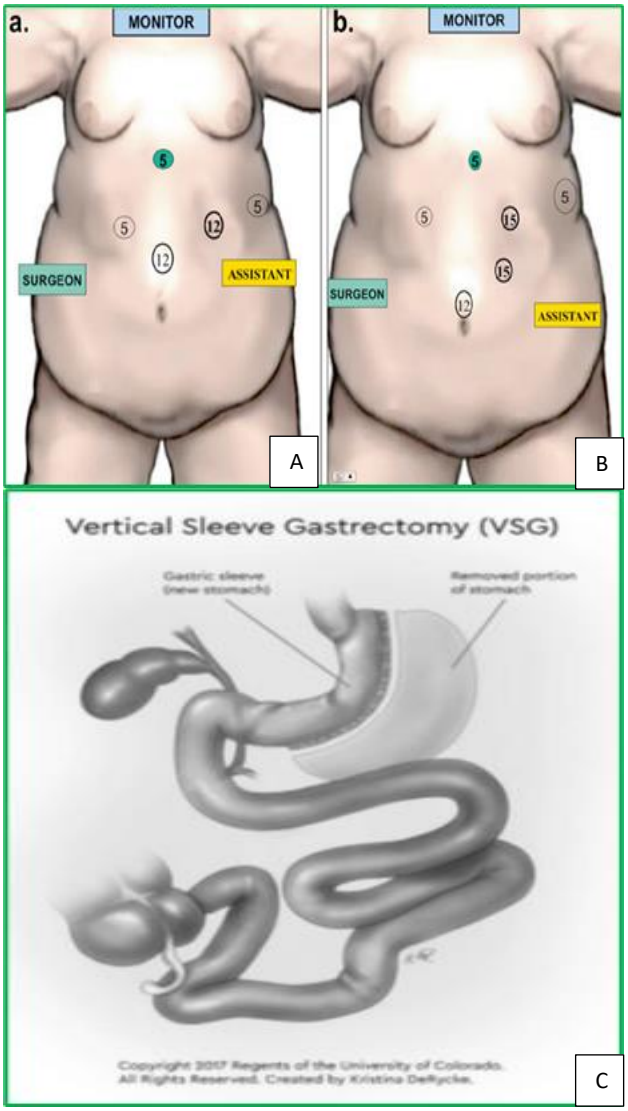

Figure 2 (A-C): Laparoscopic sleeve gastrectomy 1.

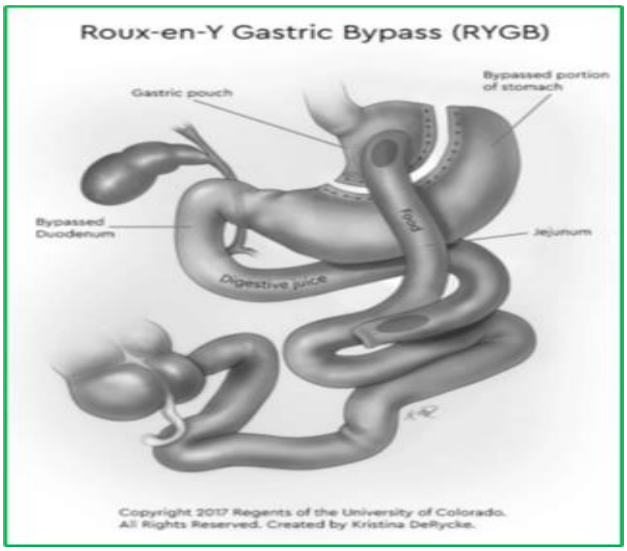

Figure 3: RYGB 1.

LITERATURE RESEARCH

Search strategy

In this systematic review, three main databases were used, namely PubMed, ScienceDirect and Cochrane Library. Keywords such as "pediatric laparoscopic sleeve gastrectomy, gastrectomy, Roux-En-Y, gastric anastomosis, adjustable gastric banding, gastric banding, pediatric gastric bypass, pediatric weight reduction surgery, pediatric weight reduction surgery, pediatric bariatric surgery, nutritional deficiencies, gastrointestinal function, gastrointestinal complications", along with Boolean operators were used in order to maximise the reach of data obtained. Example search: "Pediatric weight reduction surgery or pediatric bariatric surgery and impact gastrointestinal complications". We filtered data by date and source type. All sources used were published between 2018 and 2024 and were either clinical trials, RCTs or case reports.

Screening and data extraction

Screening and data extraction was initially performed independently by the three primary researchers SHSB, SA and AP, with a subsequent process of conferring, where ideas were suggested and corrections were made amongst all researchers. This was often in cases where data that was used may have been skewed to an adult population or strayed away from this review's focus.

The selection process is presented in Figure 4.

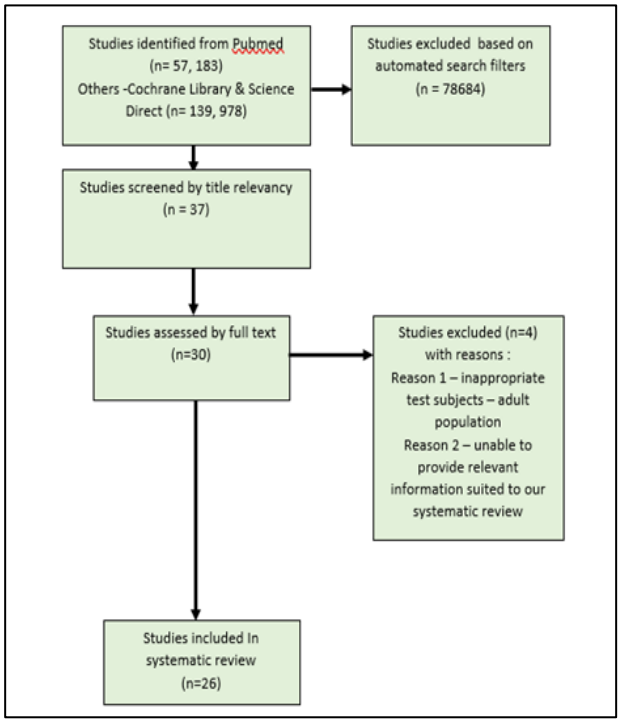

Figure 4: Flow chart of study selection 1 process.

DISCUSSION

Eligibility for surgery and comparison of bariatric surgical methods

When considering the eligibility of a given pediatric patient for bariatric surgery three main criteria are taken into account-their age, BMI and comorbidities. The WHO states that adolescence are persons between the ages of 10 and 19 years. The European society for pediatric gastroenterology, hepatology and nutrition (ESPGHAN) recommends bariatric surgery for adolescents with severe obesity and who have achieved 95% of their expected height and a BMI ≥40 kg/m^2 with severe comorbidities and BMI ≥50 kg/m^2 with mild comorbidities.[7] Comorbidities include conditions like diabetes mellitus type 2, gastro-esophageal reflux diseases and non-alcoholic steatohepatitis (NASH), among others.[8] Though ESPGHAN and NICE also consider pubertal maturity and select candidates of Tanner stage ≥4, the American society for metabolic and bariatric surgery (ASMBS) advocates for treatment irrespective of pubertal status or bone maturity as outcomes of bariatric surgery is seemingly similar between younger and older adolescents as also evidenced in the teenage longitudinal assessment of bariatric surgery (Teen-LABS) cohort.[7,8] However, there are certain contraindications that negate the option of surgery. These include when obesity is medically correctable, there is ongoing substance abuse (within the preceding year), other conditions suggestive of inability of patient to adhere to postoperative regimens, or cases of pregnancy planned pregnancy within 18 months of the procedure and lastly, the inability to obtain informed consent from either patient or caregiver.[7]

There is ongoing discussion with regards to which is considered the superior bariatric surgical method among the three-prior mentioned. Though AGB is least advocated for due to the more severe long term nutritional deficiencies it causes, LSG and RYGB have both shown promising results. While LSG is known to be a less complex method, with low complication rates, studies over the years have demonstrated similar outcomes for RYGB and LSG, with RYGB prevailing in some instances.[9] In the largest prospective study to date involving 228 adolescents, a BMI reduction of 28% was seen in RYGB compared to 26% reduction following SG, at three years post-op. Similarly, the three-year outcomes published by teen-LABS reported a mean three-year reduction of 15 kg/m^2 following RYGB compared to 13 kg/m^2 after LSG.[9,10] RYGB has also been shown to improve glycaemic control, with less post operative complications of GERD.[8] However, micronutrient deficiencies remain a risk for RYGB too and the need for re-operation has been reported for both RYGB and LSG. The TEEN-best study, an ongoing 5-year randomised control trial that begun in 2020 aims to determine which of RYGB and LSG is superior, though it hypothesises no superiority. It measures the outcomes in terms of primary

and secondary outcomes. Primary meaning a total body weight loss of 20% at 3 years post-op and secondary outcomes which include criteria such as BMI, status of comorbidities, bone health and body composition.[9]

Short term outcomes

Paediatric patients experience short-term complications (<30 days post-surgery) that are similar to those experienced by adult patients.[11] However, adolescents are safer candidates for metabolic and bariatric surgery (MBS) than adults since the rate of short-term complications (5.5% vs 9.8%) and in-hospital mortality following RYGB (0% vs 4.3%) was significantly lower. Early post-operative problems include bleeding (0.4%), leaks (0.4%), deep surgical site infections (0.2%), strictures, and thromboembolism; as a result, the average inpatient stay is 1-3 days to monitor for these events. Compared to sleeve gastrectomy (SG), RYGB has more serious short-term consequences, including higher rates of readmission (6.3% vs. 3%), major complications (5.5% vs. 1.8%), reoperation (2.1% vs. 0.8%), and 30-day morbidity (4.3% vs. 0%). Following MBS, patients initially follow a high-protein liquid diet and progress to incorporating high-protein meals three to four times per day. To avoid dehydration, patients are urged to consume supplemental sugar-free fluid between meals. Due to MBS being a restrictive procedure, fewer nutrients are consumed leading to lifelong issues; there is a significant danger of iron, vitamin B12, and vitamin D deficiency, so supplementation is initiated. Adolescents undergoing RYGB show improvements in obesity-related cardiovascular risk factors, including altered glucose metabolism, plasma lipids, and blood pressure. The pediatric Bariatric Study Group reported significant weight loss and resolution of metabolic comorbidities within the first-year post-op. Living quality and psychological effects also improved.[12]

Long term outcomes

Examining long-term complications is pivotal in understanding the broader impacts of bariatric surgery.

In one randomized control trial, of patients aged 18, who underwent RYGB and ne anastomosis gastric bypass (OAGB) years post-revision surgery, both groups demonstrated significant improvements in dyslipidemia, hypertension, and type 2 diabetes. Though initially patients exhibited reductions in BMI after revision surgery, decreasing from 44.9±6.6 kg/m^2 and 45.1±8.3 kg/m^2 pre-revision to 27.8±2.2 kg/m^2 and 27.4±3.1 kg/m^2 2 years post-revision, weight regain ensued afterwards.[13] Data shows that LSG candidates experienced a higher incidence of weight regain and weight loss failure, which are deemed as long-term complications following bariatric procedures. Another source shows that patients often experience significant weight loss in the first 12-18 months post operation and tend to plateau around the 18-month mark.[14]

The most prevalent long-term complication reported is nutritional deficiencies, particularly iron, vitamin D, and vitamin B12 insufficiency. Iron deficiency anemia, often attributed to menstruation in premenopausal women, can be addressed with iron infusion. RYGB patients face an elevated risk of vitamin B12 insufficiency due to anatomical changes leading to malabsorption. Elevated parathyroid hormone concentration after 5 years suggests calcium deficiency, raising concerns about its impact on bone health.[15] Deficiencies are more prevalent in patients exhibiting non-adherence to prescribed postoperative prophylactic supplements.[16]

Another frequently occurring complication is cholelithiasis. This occurs as a result of rapid weight loss due to bariatric surgery. According to teen-LABS study, further intervention is needed in 9.9% patients who underwent RYGB initially, have to undergo cholecystectomy within 3 years.

Transitioning to metabolic outcomes, a study conducted over a 5-year period sheds light on the postoperative effects of type 2 diabetes mellitus (T2DM). All four participants with T2DM at baseline achieved clinical remission, while in teen-LABS, the prevalence of T2DM dropped from 14% to 2.4%. Bariatric surgery's impact on T2DM remission and metabolic control surpasses other interventions in obese adolescents.

Furthermore, modelling future cardiovascular risk with the Framingham CVD event score revealed that bariatric surgery significantly lowered risk compared to medical intervention at 1 and 5 years of follow-up. Alongside these cardiovascular benefits, surgery demonstrated notable improvements in diabetes and obesity-related kidney issues, including hyperfiltration and elevated urinary albumin excretion, in obese adolescents with T2DM compared to medical therapy.

Non-alcoholic fatty liver disease (NAFLD) is prevalent among obese adolescents. While non-alcoholic steatohepatitis (NASH), a significant complication in bariatric surgery guidelines, is less common, a dose-response relationship exists between weight loss and liver inflammation, ballooning, and the resolution of NAFLD or NASH.

Moreover, severely obese adolescents commonly experience hypertension. Both AMOS and TEEN-LABS studies demonstrate impressive hypertension remission at 2- and 5-years post-surgery. In the AMOS study, 100% of bariatric patients achieved complete resolution, while teen-LABS reported a 68% remission rate.

Increasing evidence links bariatric procedures to adverse skeletal effects, potentially stemming from vitamin D deficiency, mechanical unloading due to weight loss, and a sudden decrease in leptin concentration. Sleeve gastrectomy not only reduces bone mass independently of weight loss or nutrient deficiencies but also leads to

elevated markers of bone turnover persisting beyond the majority of weight loss. This reduction in bone mineral density significantly increases fracture risk with long-term risk being greater for RYGB compared to sleeve gastrectomy. Fracture risk becomes apparent more than 2 years after the initial bariatric procedure and continues to rise in subsequent years.[17]

In the AMOS study, over 5 years, at least 20 surgical patients had 21 additional abdominal interventions, primarily for intestinal obstruction (11 procedures) and symptomatic gallstones (9 procedures). The surgical group had a longer cumulative in-hospital stay than the control group.[18] The data highlights a significant need for additional abdominal interventions, particularly for concerns like intestinal obstruction and symptomatic gallstones over a 5-year period. This is reflected in the longer cumulative in-hospital stay for the surgical group, indicating heightened healthcare resource utilization.

Quality of life

Adolescents grappling with obesity often face psychosocial stress, stigmatization, and socio-economic disadvantages, contributing to a heightened likelihood of purposefully avoiding social situations. This avoidance can lead to a detrimental cycle of social isolation, impacting academic achievements and potentially hindering their ability to lead an independent adult life. Additionally, these adolescents are at an increased risk of developing mental health disorders linked to weight gain.[14]

Following bariatric surgery, adolescents experience improved quality of life within the first year due to weight loss. Despite this initial improvement, long-term studies tracking these adolescents five years later reveal that there is no significant "improvement in their existing mental health disorders. Any improvements tend to be short-lived, and individuals may regress to their mental health issues despite the achieved weight loss. However, a positive outcome directly resulting from bariatric surgery is the reduction in “self-reported problems with binge eating and uncontrolled eating” after 5 years.[14] Notably, at the 5-year post-surgery mark, patients report significant improvements in self-esteem, although overall mood remains unchanged from baseline.[17]

Alternatives to surgery

In the pursuit of weight loss and management, individuals often explore various medical methods that do not necessitate surgical intervention. These approaches, often complemented by lifestyle adjustments like dietary modifications and increased physical activity, offer viable alternatives to surgical procedures.

Prescription medications are crucial for weight loss, employing mechanisms like appetite suppression and fat absorption inhibition. Notable examples include Orlistat and phentermine/topiramate (PHEN/TPM). Liraglutide, initially curated for diabetes, aids weight loss by modulating appetite. Glucagon like peptide-1 (GLP-1) regulates glucose metabolism, suppressing appetite. Liraglutide, a GLP-1 receptor agonist, reduces visceral fat in obese adults.[19] Recent studies show two doses of PHEN/TPM in obese adolescents result in significant weight loss.[20] Medical weight loss programs, including counselling, exercise, and medications, are effective for overweight/obese adults. high-intensity interval training achieves 3kg more weight loss than moderate-intensity continuous training.[21] Intermittent energy restriction showed weight loss over 24 weeks.[21] Meal replacement products offer controlled calorie intake, reducing serum leptin levels in overweight individuals.[22] Medical devices like gastric balloons induce fullness, promoting 7.1-10.7% weight loss in six months. Drawbacks include discomfort and reduced effectiveness.[23] vBloc aids moderate obesity patients but may require removal due to issues. Laparoscopic removal has low 30-day complication rates.[24] Transcatheter bariatric embolotherapy, targeting ghrelin, reduces blood perfusion, resulting in an average 8-9 kg weight loss, about 8-9% of baseline weight.[25]

CONCLUSION

In conclusion, paediatric weight reduction surgery serves as a pivotal intervention in addressing the escalating prevalence of adolescent obesity, a concern linked to increased mortality risk and various complications. Surgical options like sleeve gastrectomy and gastric bypass offer significant weight loss and resolution of obesity-related comorbidities, particularly in adolescents with severe obesity. Debates continue over the superiority between LSG and RYGB in bariatric surgery. LSG is preferred for its simplicity and lower complication rates. Studies show comparable outcomes, but RYGB offers advantages in BMI reduction, glycemic control, and fewer postoperative complications of GERD. However, both procedures pose risks of micronutrient deficiencies and potential reoperation.

Eligibility criteria for obesity hinges on age, BMI, and comorbidities with contrasting criteria among organisations. While pubertal maturity is considered by some, others advocate for treatment regardless of pubertal status, emphasising similar outcomes across age groups. However, contraindications such as non-surgically correctable obesity, substance abuse, and noncompliance with postoperative regimens remain critical in-patient selection.

Short-term complications are manageable, with adolescents showing lower rates compared to adults. However, long-term nutritional deficiencies and other complications necessitate lifelong monitoring and support. While surgery improves quality of life initially, sustained mental health benefits are uncertain.

With ongoing research, comparing surgical methods and assessing long-term outcomes, paediatric weight reduction surgery continues to evolve, offering hope for improved health and well-being in adolescents combating obesity. A multidisciplinary approach is imperative in evaluating candidates for surgery and guiding postoperative management. While medical and lifestyle interventions remain valuable, surgical intervention proves superior, especially in severe cases.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

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Cite this article as: Shankar Babu SH, Atiq S, Prasad A, Yankov I. What are the realms of pediatric weight reduction surgery and what is its influence on digestive wellbeing? Int J Contemp Pediatr 2024;11:1499-505.