Obesity and bariatric surgery; History, current state and prospects

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Abstract

Obesity is a worldwide pandemic as well-defined by World health organization. Its causes are multiple and complex and its complications are innumerable and profound with tangible impact on morbidity and mortality. There has been a rise in prevalence of obesity worldwide in the past decades, with notable rise in childhood obesity especially in middle- and low-income countries. So far, bariatric surgery has been the most effective long-term treatment of obesity as shown by many studies. Bariatric surgery has been through a long journey since its first conception around the middle of the past century. Many procedures have been innovated then fallen out of use due to complications or low benefit, while others have prevailed and became established in practice, such as Roux-en-Y gastric bypass and sleeve gastrectomy. Many other procedures are recently innovated and are currently being investigated. This is an overview of the obesity problem worldwide, with a review of the evolution of bariatric surgery till its current state today.

Keywords:Bariatric Surgery; Obesity; Current State

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I- Definition of Obesity:

The World Health Organization (WHO) defines obesity as a condition of excessive fat accumulation in the body to the extent that health and well-being are adversely affected**[1].**

II- Epidemiology

A- Prevalence

Obesity is a chronic disease that is increasing in prevalence around the world. In a 2013 to 2014 report, the prevalence of obesity in men was approximately 35 percent but increased in women to 40.4 percent **[2]**. In Canada, fewer than 10 percent of people were obese in all nine provinces in 1985, By 2013, more than 22 percent of men and 20 percent of women were obese, a steady and distressing increase. These data and those from other countries are indicative of a major international epidemic. Mean BMI is increasing worldwide. In developed countries, obesity rates in 2013 were approximately 18 and 20 percent in men and women, respectively. In 2013, reported prevalence rates of obesity by country included 21 percent of men and 23 percent of women in Belgium, 25 percent of men and women in the United Kingdom, 20.6 percent of men and 33 percent of women in Mexico, 12.3 percent of men and 41 percent of women in South Africa, and 14 percent of men and women in Pakistan. Despite the wide range across countries, data suggest that the percentage of obesity has increased in most populations over the past 30 years **[3].**

It is difficult to directly compare prevalence rates between countries because of differences in parameters and dates of measurements. However, studies using comparable statistics show that rates are particularly high (greater than 30 percent) in most countries in North and South America, as well as in Great Britain, Greece, Italy, Malta, Portugal, and Spain. There are somewhat lower rates in the Nordic countries, and the central portion of Western Europe. In Russia and most

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of the countries of Eastern Europe, the prevalence of overweight is lower (about 15 percent) but increasing. In China, the prevalence of overweight among children is approximately one-half of that in the United States, but rates are substantially higher in young children than in adolescents **[4]**.

Worldwide, overweight and obesity in children have increased across a wide range of resource-rich and resource-poor countries during the past 50 years. The rate at which childhood obesity is increasing in middle- and low-income countries is 30 percent higher than the rate of increase in high-income countries **[5]**.

B- Risk factors

The prevalence of childhood overweight and obesity is high in most resource-rich countries worldwide. About one-third of children and adolescents in the United States are either overweight or obese. Having one obese parent increases the risk of obesity by two- to threefold, and up to 15-fold if both parents are obese. Obesity is also more prevalent among low-income populations; for example, 14.9 percent of low-income preschool-aged children were obese in 2010, compared with 12.1 percent in this age group in the general population **[6].**Many, but not all, obese children will become obese adults. The likelihood of persistence of childhood obesity into adulthood (sometimes called "tracking") is related to age, parental obesity, severity of obesity, and BMI trajectory during childhood. These observations provide support for the concept of interventions early in life to prevent and treat obesity **[7]**.

III- Etiology

Obesity results from a net positive energy balance (energy intake greater than energy expenditure) over time, so many physiologic systems (endocrinal, gastrointestinal, central nervous, peripheral nervous and cardiovascular) affect these functions **[8].**The cause of obesity is complex and multifactorial. The contributing factors include genetic, environmental, socioeconomic, behavioral, psychological, metabolic and endocrine factors **[9]**.

IV- Assessment of obesity patient

Body fat can be measured by different techniques including densitometry, hydrometry, dual energy X-ray absorptiometry (DXA), chemical multi-compartment models, computed tomography (CT), or magnetic resonance imaging (MRI). These methods are not suited for use under clinical conditions and in population-based studies, as they are too sophisticated, costly and time consuming to be used on a large scale or repeated follow up. There are a number of other methods available for large-scale use that can predict body fat (BF) percentage, these include skin fold thickness measurements, bioelectrical impedance, the use of body mass index (BMI) and waist circumference, and the more recently described body adiposity index (BAI) **[10].**

- **Waist circumference**: measured at two locations: smallest abdominal circumference (waist circumference) and at the umbilicus (umbilical circumference), under the clothes and at the end of a normal expiration**[11].**
- **Hip circumference:** measured at the greatest circumference of the gluteal region.**[11]**
- **Waist-to-hip ratio (WHR):**calculated using the waist circumference and hip circumference measures.**[11]**
- **Body Mass Index (BMI):** calculated by dividing the weight in kilograms by the square of height in meters [BMI = weight (kg) / height (m^2)] **[12]**. Obesity is commonly assessed using BMI which is a convenient parameter for documenting the incidence of obesity and for setting clinical guidelines **[13]**.
- **Percentage excess body weight (% EBW)**: defined as [(Actual weight – Ideal weight) / Ideal weight] ×100, where ideal or normal

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weight is usually determined by a BMI of 25kg/m^2**[14]**.

- **Percent excess body weight loss (%EBWL)**: calculated by dividing the difference between initial BMI and final BMI by the difference between initial BMI and the normal target BMI**[14].**
- Overweight is defined as a BMI in the 25 to 29 kg/m^2 range, whereas obesity is a BMI in excess of 30 kg/m^2**[15]**. The National institute of health (NIH) in USA classified obesity into three classes according to BMI:

➢ Class 1 obesity with a BMI between 30 and 34.9 kg/m^2.
➢ Class 2 obesity with a BMI between 35 and 39.9 kg/m^2 and
➢ Class 3 obesity or severe obesity with a BMI of 40 kg/m^2 or higher. Morbid obesity is defined as a BMI of 40 Kg/m^2 or greater, or a BMI of 35 kg/m^2 with obesity related comorbidities. Superobesity is a term sometime used to define individuals who have a BMI of 50 Kg/m^2 or greater **[16].**

There is growing evidence that for Asian patients, the BMI criteria can be lowered by 2.5 kg/m^2 per class related to a higher prevalence of truncal obesity (i.e., visceral fat), which is felt to be more hazardous than peripherally located fat **[17]**.

VI- Obesity related morbidities and complications

Fat distribution & central obesity ➔ Accumulating data suggest that regional fat distribution substantially affects the incidence of comorbidities associated with obesity. Android obesity, in which adiposity is predominantly abdominal (including visceral and, to a lesser extent, subcutaneous), is strongly correlated with worsened metabolic and clinical consequences of obesity. Waist circumference as well as waist-to-hip ratios directly correlate with cardiovascular risk **[18].**

Obesity is associated with a wide spectrum of pathology collectively referred to as metabolic diseases. Multiple large epidemiologic studies documented increasing risk for metabolic diseases and long-term mortality with increasing BMI in obese subjects, while overweight (BMI 25–30) subjects suffer similar increased risks albeit at lower risk ratios **[19],**including: impaired glucose tolerance and Diabetes mellitus, cardiovascular disease,obstructive sleep apnea syndrome (OSA), gall bladder disease, gastro-esophageal reflux diseases, fatty liver and steatohepatitis, osteoarthritis and joint diseases, sex hormones and reproductive disorders,hernia risk with obesity,cancer and psychological morbidities.

VII- Treatment of obesity

Measures to treat obesity involve a wide spectrum of approaches. Ranging from life style modifications through diet, exercise and behavioral modifications, up to drug therapy and surgery.

- **Bariatric surgery**

The aforementioned approaches to weight loss may be ineffective for many obese individuals. Hence, bariatric surgical procedures are increasingly common worldwide because of their efficacy in weight reduction and improved management of diabetes and hypertension. Bariatric surgery has been the most successfulapproach inmanaging clinically severe obesity in terms ofachieving and sustaining great weight loss for a long period**[20]**.The co-occurrence of metabolic risk factors for both type 2 diabetes and CVD (abdominal obesity, hyperglycemia, dyslipidemia, and hypertension) suggested the existence of a "metabolic syndrome". In recent years, the majority of researchers in the field recognize that the most effective models of classic bariatric surgery work because of the hormonal changes they provoke. As such, they started calling this surgical specialty ‘‘Bariatric and Metabolic

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Surgery'' **[21]**. Operating on obese patients is challenging because of anatomic and physiologic characteristics and comorbidities of such patients. However, the risk of serious intraoperative and in-hospital complications and mortality rates are relatively low when the surgery is performed by experienced surgeons with an institutional investment in bariatric programs. In addition, obese patients who undergo bariatric surgery have lower long-term mortality rates compared with matched controls who did not have bariatric surgery**[22]**. In a survey from the International Federation for the Surgery of Obesity and Metabolic Disorders, Bariatric surgery is one of the fastest-growing operative procedures performed worldwide. Approximately 340,770 bariatric procedures were performed worldwide in 2011 **[23].**The most frequently performed procedure in this survey was sleeve gastrectomy **(Figure1).**

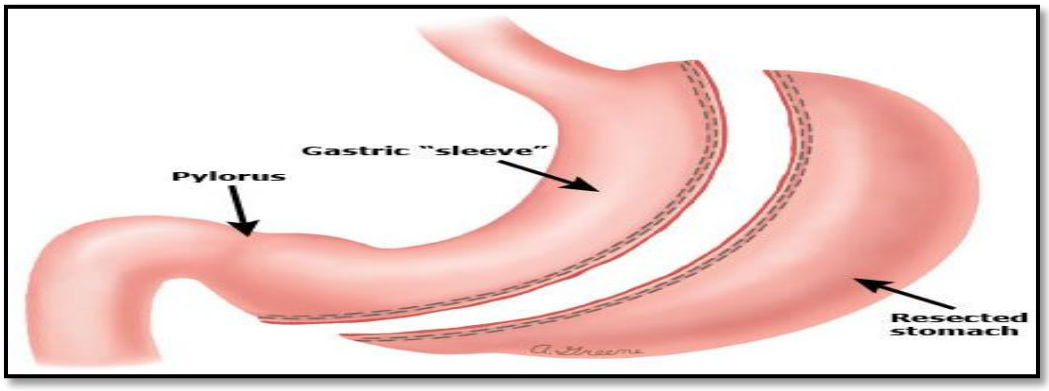

Fig. (1): Sleeve gastrectomy – illustration[24].

Brief History and types of procedures

The first bariatric surgery reported in history was in Spain in the 10th century. D. Sancho, king of Leon was such an obese man that he could not walk, ride a horse or pick up a sword. This led him to lose his throne. He was then taken to Cordoba to be treated by the famous Jewish doctor HasdaiIbnShaprut, who sutured the kings' lips so he could only be fed a liquid diet through a straw, consisting of a mixture of several herbs, including opium, whose side effects stimulated weight loss. King Sancho lost half his weight, returned to Leon in his horse and regained his throne**[25]**.

Even though specific weight loss interventions are sporadically reported throughout literature in the second half of the 20th century, they remained in obscurity until the 1990s. It was only when the obesity epidemics got finally recognized that the medical community started considering surgical approaches to tackle it **[26].** The first metabolic surgery is attributed to Kremen in 1954: the jejuno-ileal bypass**[27].** It was devised to treat severe forms of dyslipidemia. It had major metabolic consequences, such as most patients suffered from severe diarrhea and dehydration, so it didn't gain popularity. Several modifications of intestinal bypass procedures were reported in the 1960s and 70s,but none of them gained widespread acceptance **[28].**

In 1966, Dr. Mason, noting that patients with subtotal gastrectomy for cancer lost a considerable amount of weight, proposed the first "bariatric surgery": the first gastric bypass. Most of stomach was excluded except an estimated 20 per cent of the fundus that was anastomosed to the jejunum at a point 24 inches beyond the ligament of Treitz. A Polyagastroenterostomy was performed anterior to the colon. The distal closed segment of stomach was sutured to the anterior surface of the fundic segment**[29].** Compared to jejuno-ileal bypass, gastric bypass procedures resulted

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in less diarrhea, kidney stones, gallstones and improvement in liver fat content **[30].** In 1994, the first laparoscopic gastric bypass was performed by Alan Wittgrove and the exponential growth of bariatric and metabolic surgery had definitely started, and Roux-en-Y Gastric Bypass (RYGB) was the most common procedure **[28].**

Laparoscopic Roux-en-Y gastric bypass is a technically challenging surgery with a steep learning curve and with potential leaks at 2 anastomoses. In an attempt to make it simpler and safer, Rutledge developed the Mini-Gastric Bypass **[31]** (or omega-loop or single-anastomosis gastric bypass), consisting of a longer gastric pouch and an antecolic loop gastrojejunostomy 150–200cm distal to the angle of Treitz. His first surgery was in 1997 and although Rutledge published his experience with thousands of patients **[32]**, this technique has suffered criticisms of biliary reflux and risk of malignancy for several years. Increasing experience with this technique worldwide has reduced these concerns and in the latter years it gained wide acceptance among surgeons **[33,34].**

Purely restrictive procedures were also developed as an alternative to gastric bypass. These techniques were thought to have less surgical morbidity and mortality and to be simpler to perform. As early as 1977, Rodgers et al. reported on their experience with 17 cases of jaw wiring. The early weight loss was comparable to gastric bypass procedures, however patients regained weight after the wires were removed **[35].** The first restrictive procedure on the stomach consisted of a"Nissen-type" gastric wrap, proposed by Wilkinson **[36]**. Since then, several gastroplasties had been proposed. The most accepted procedure was the vertical banded gastroplasty (Figure2), proposed by Mason **[37]**. It combined a vertical stapled gastroplasty with a banded outlet. The great improvement with the gastric band occurred in 1986, when Kuzmak**[38]**allowed the band to be adjusted without the need for further surgical explorations. There was an exponential increase in the number of these procedures after the introduction of the laparoscopic technique. The first laparoscopic gastric band was placed by Cadière in 1992 **[39].** It was an easy, fast, reproducible technique with low perioperative morbidity, but was almost abandoned in the latter years due to long-term complications (e.g. stricture, vomiting, reflux and band erosion) and failure in weight loss **[28].**

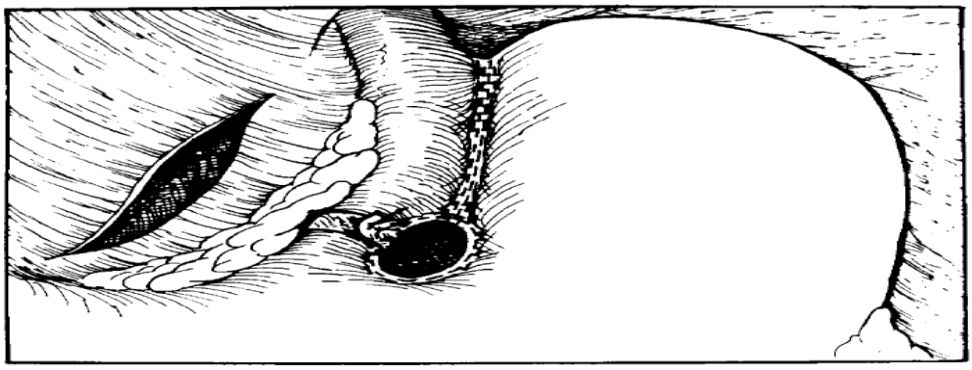

Fig. (2): Vertical banded gastroplasty[37]

On the other hand, some surgeons believed that malabsorption was required for successful weight loss, and proposed a significant change to the technique. Scopinaro published the experience on human subjects that underwent bilio-pancreatic diversion (still called the Scopinaro procedure) **[40]** (Figure 3)**.** The surgical technique included a distal

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gastrectomy with a long Rouxlimb and a short (50 cm) common channel. Scopinaro reported weight loss greater than 79% maintained up to 25 years **[41],** because patients absorption capacity was limited to ~1250 kcal/day. He also reported a low complication rate, mostly with anemia, protein malnutrition and stomal ulceration. However,Scopinaro's results were not replicated elsewhere and several modifications to his technique were proposed. The most accepted of this alternative is Duodenal Switch (Figure 16), reported by Marceau and Hess **[42,43],** The changes included substituting the distal gastrectomy for a vertical (sleeve) gastrectomy, thus preserving vagal innervation and pyloric function. Then proceeding with a duodeno-ileal anastomosis at 100 cm from the ileo-cecal valve (elongating the common alimentary channel). This alternative technique of bilio-pancreatic diversion yielded the same weight loss with a lower complication rate **[42].**

Biliopancreatic diversions are very complex surgeries that still remain a challenge even to the most experienced laparoscopic surgeons. For this reason, Gagner proposed that it could be done as a staged procedure, starting with a vertical (sleeve) gastrectomy and proceeding with the duodenal switch **[44].**

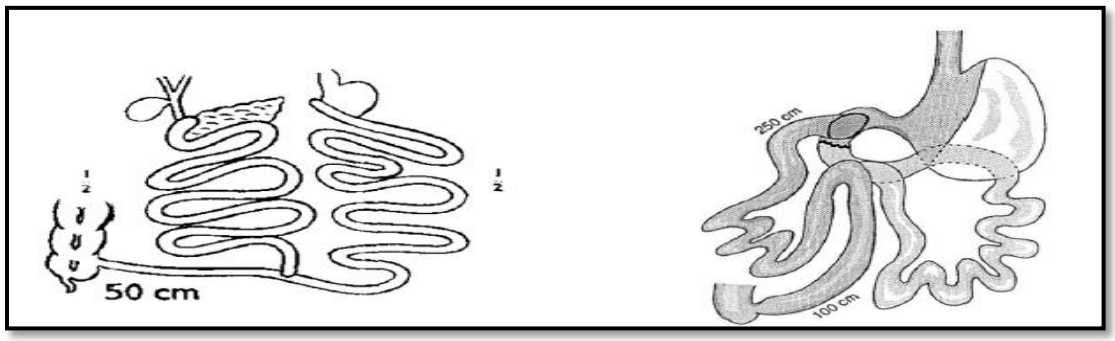

Fig. (3): Bilio-pancreatic diversion (left),Modification with duodenal switch (right) [40,42].

The challenge of laparoscopic surgery in super superobese patients (BMI > 60 kg/m^2) led to the proposal of a staged procedure for gastric bypass, where sleeve gastrectomy would also be the first part **[45].** The observation that these patients lost a significant amount of excess weight (56%), combined with previous experience in the UK with the "Magenstrasse and Mill" operation (Figure4)**[46].** (a vertical gastric partitioning without gastric resection, with a small curvature centered sleeve), led some authors to propose sleeve gastrectomy as a stand-alone surgery for the treatment of obesity. Since then, laparoscopic sleeve gastrectomy has risen in popularity until becoming now the most commonly performed bariatric procedure. **[23]**

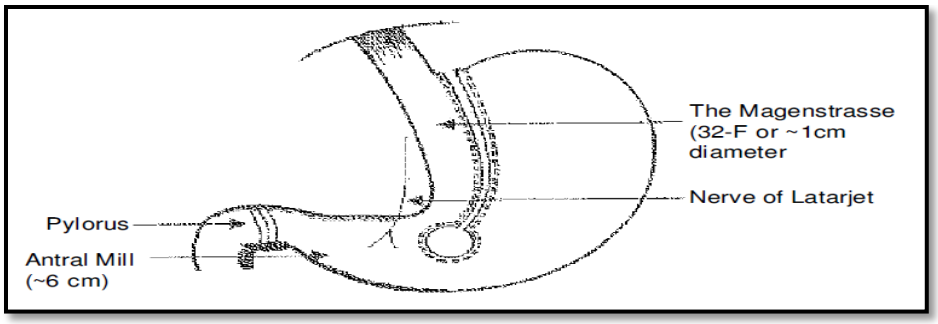

Fig. (4): The Magenstrasse and Mill operation[46]

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Criteria for patient selectionfor the surgical management of severe obesity were first outlined by the National Institutes of Health (NIH) Consensus Development Panel and reviewed by the American Bariatric Society in 2004.Candidates for a bariatric surgical procedure include **[47]**:

- Adults with a BMI ≥**40** kg/m^2 without comorbid illness**[48,49]**.
- Adults with **a** BMI 35.0 to 39.9 kg/m^2 with at least one serious comorbidity, including the following - but not limited to them[50,51]:Type 2 diabetes [52], obstructive sleep apnea (OSA), hypertension, hyperlipidemia, obesity-hypoventilation syndrome (OHS), pickwickian syndrome (combination of OSA and OHS), nonalcoholic fatty liver disease (NAFLD), nonalcoholic steatohepatitis (NASH), pseudotumorcerebr, gastroesophageal reflux disease, asthma, venous stasis disease, severe urinary incontinence, debilitating arthritis, impaired quality of life and disqualification from other surgeries as a result of obesity (i.e. surgeries for osteoarthritic disease, ventral hernias, or stress incontinence).
- Adults with BMI between 30.0 to 34.9 **kg/m**^{2} AND one of the following comorbid conditions as uncontrollable type 2 diabetes and metabolic syndrome**[52].**N.B Although there is no long-term evidence of benefit to support routinely performing a bariatric operation. There is growing evidence that for Asian patients, the BMI criteria can be lowered by 2.5 kg/m^2 per class related to a higher prevalence of truncal obesity (i.e., visceral fat), which is felt to be more hazardous than peripherally located fat **[17]**.

Contraindications:

Bariatric procedures should not be performed for glycemic or lipid control or for cardiovascular risk reduction independent of the body mass index (BMI) parameters **[47].Bulimia nervosa** rare in patients with severe obesity, such patients are not candidates for bariatric procedures **[47]**.In addition, bariatric surgery in advanced (above 65 years) or very young age (under 18 years) is controversial but is considered when comorbidity is severe **[53]**.Other medical or psychiatric conditions that preclude a bariatric surgical procedure**[54]** as untreated major depression or psychosis**, u**ncontrolled and untreated eating disorders (e.g., bulimia), current drug and alcohol abuse, severe cardiac disease with prohibitive anesthetic risks**, s**evere coagulopathy and inability to comply with nutritional requirements including life-long vitamin replacement**.**

Overall mechanism of weight loss

Bariatric surgical procedures affect weight loss through two fundamental mechanisms: malabsorption and restriction. Some procedures have both a restrictive and malabsorptive component. Therefore, procedures are broadly classified into restrictive, malabsorptive or combined restrictive and malabsorptive procedures. There is also growing recognition that bariatric surgical procedures contribute to neurohormonal effects on the regulation of energy balance **[55,56]**.

Restriction: Restrictive procedures limit caloric intake by reducing the stomach's reservoir capacity via resection, bypass, or creation of a proximal gastric outlet. Vertical banded gastroplasty (VBG) and laparoscopic adjustable gastric banding (LAGB) are purely restrictive procedures and share similar anatomical configurations. Both limit solid food intake by restriction of stomach size as the only mechanism of action, leaving the absorptive function of the small intestine intact. These procedures have largely been abandoned. The sleeve gastrectomy has become the main restrictive procedure, but it is probably more

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successful due to its effects on hunger control. Investigational procedures, such as intragastric balloon placement or aspiration therapy, also work by restricting food intake but produce more gradual and modest weight loss compared with other contemporary surgical procedures **[57].**

Malabsorption: Malabsorptive procedures decrease the effectiveness of nutrient absorption by shortening the length of the functional small intestine, either through bypass of the small bowel absorptive surface area or diversion of the biliopancreatic secretions that facilitate absorption. Jejunoileal bypass (JIB) and the biliopancreatic diversion (BPD) are examples of malabsorptive procedures. Profound weight loss can be achieved by a malabsorptive operation, depending upon the effective length of the functional small bowel segment. However, the benefit of superior weight loss can be offset by significant metabolic complications, such as protein calorie malnutrition and various micronutrient deficiencies **[58].**

Combination of restriction and malabsorption: The Roux-en-Y gastric bypass (RYGB) and BPD with duodenal switch (BPD/DS) are both restrictive and malabsorptive. In the RYGB, a small gastric pouch limits oral intake. However, the small bowel reconfiguration provides additional mechanisms favoring weight loss, including dumping physiology, positive hormonal changes, and mild malabsorption. There is an effect on hunger as well, likely due to the hormonal changes**[55, 59].**

Current state:

Bariatric surgery is now a mainstream practice and still rising in frequency. The landscape includes many already established popular procedures, as well as new investigative procedures that are approached in hope of better results or proving less risk and complications than conventional procedures

A) Contemporary procedures**[60].**

- **Roux-en-Y gastric bypass** — The Roux-en-Y gastric bypass (RYGB)**(Figure5)** remains one of the most commonly performed bariatric procedures. The origin of Laparoscopic RYGB (LRYGB) can be traced back to about 50 years ago. As LRYGB has excellent effectiveness on alleviating obesity complications, including type 2 diabetes (T2DM), it is known as the gold standard surgery for obese patients. However, impaired micronutrient absorption (examples) is more common after LRYGB**[61].**

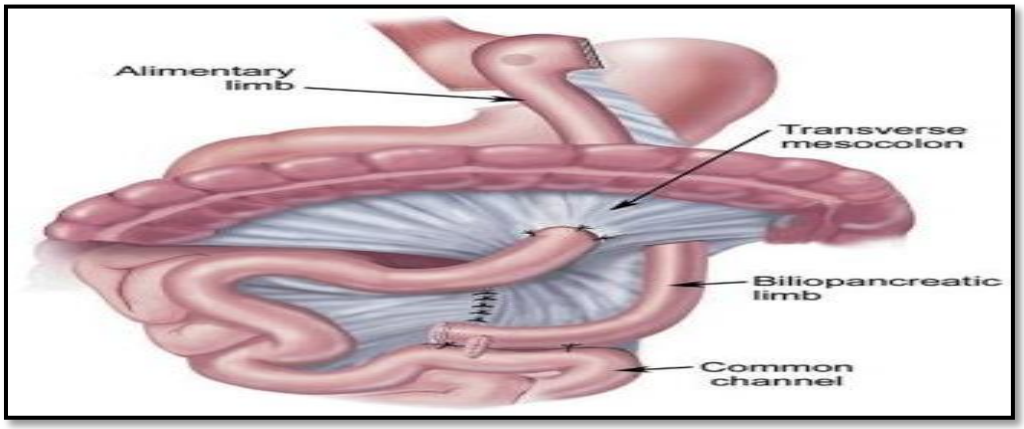

Fig. (5): RYGB – illustration.**[62]**

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Global trends show an overall relative decline in performing RYGB (parallel to rise of LSG) from approximately 65 percent in 2003 to 35 percent in 2019 of all bariatric procedures performed**.** Biliopancreatic diversion with duodenal switch, Mini-gastric bypassand Sleevegastrectomy**(Figure 7,8)[63].**

B) Investigational procedures[60]: Including

- **intragastric balloon(Figure 8).**
- **Vagal blockade** in whichthe abdominal vagal nerve controls gastric emptying and signals the satiety center in the brain. A surgically implanted device that sends intermittent electrical pulses to the abdominal vagal nerve has been approved by the FDA as a possible treatment for obesity.
- **Aspiration therapy** induces weight loss by removing a portion of ingested caloric intake after each meal via a modified percutaneous endoscopic gastrostomy tube system.
- **One-anastomosis gastric bypass**
- **Single anastomosis duodeno-ileal bypass**
- **Single anastomosis sleeve ileal bypass**
- **Endoluminal vertical gastroplasty**
- **Endoscopic gastrointestinal bypass devices:** Obsolete procedures: no longer or rarely performed**[60].**
- **Laparoscopic adjustable gastric banding**
- **Jejunoileal bypass**
- **Gastroplasties**

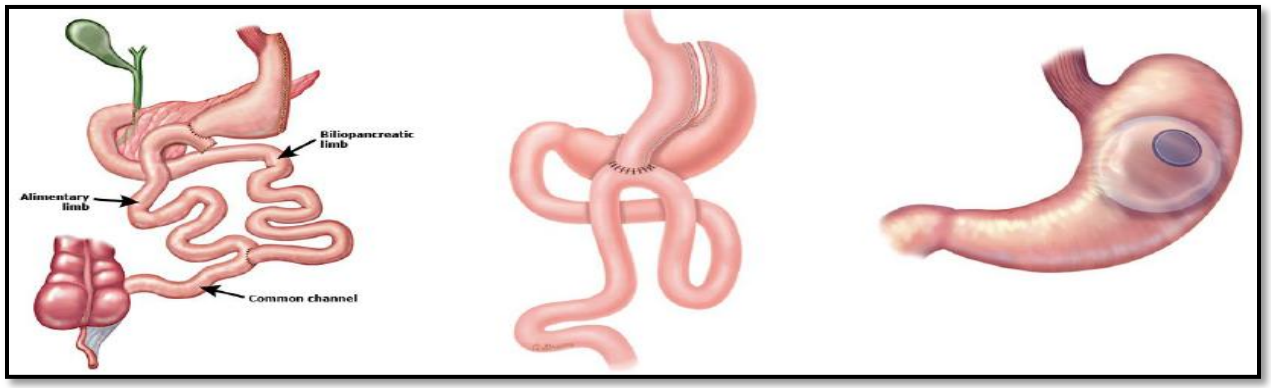

Fig. (6,7,8): BPD-DS, Mini-gastric bypass and Intragastric balloon[64]

Conclusion

Obesity is still a very present problem causing significant burden on healthcare systems and resources, where an optimal or definitive treatment is not yet established. Bariatric surgery has become at the frontline of the efforts to combat the problem, and many procedures have now become mainstream practice with a wealth of experience and results in literature such as RYGB, mini-gastric bypass and sleave gastrectomy. However, there is still a significant percentage of complications and undesirable outcomes. Hence, the continuing research into innovating modifications and new alternative procedures.

No conflict of interest.

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