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Duodenal Transit Bipartition: A Versatile Metabolic Procedure

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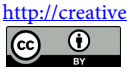

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Abstract

This article is a narrative review with the main objective of describing the technical versatility of Duodenal Transit Bipartition (DTB). DTB represents an adaptation of the classic transit bipartition concept, in which the anastomosis is shifted to a post-pyloric position in the duodenum. This technical modification preserves the pylorus and gastroduodenal continuity while creating a second pathway that directs part of the gastrointestinal content—along with bile and pancreatic secretions—early to the distal intestine. The procedure is characterized by its high technical versatility, allowing different combinations with gastric procedures (Laparoscopic Sleeve Gastrectomy, Endoscopic Sleeve Gastroplasty, or proportional Gastric Sleeve), different anastomotic techniques (manual, stapled, or magnetic), and different anastomotic locations along the duodenal segments. From a physiological standpoint, DTB probably promotes early stimulation of distal enteroendocrine L cells, potentially increasing postprandial secretion of GLP-1 and PYY. Additionally, the early arrival of bile acids to the ileum may activate the FXR-FGF19 and TGR5-GLP-1 pathways, influencing hepatic metabolism, hormonal secretion, and energy balance. It would not be appropriate to attribute the metabolic effects of DTB, or other metabolic surgical procedures, exclusively to a single mechanism. The metabolic benefit of these metabolic procedures likely derives primarily from the interaction between anatomical alterations, nutrient flow, intestinal signaling, bile acids, and secondarily from caloric reduction and weight loss. The preservation of pyloric control may reduce the risks of dumping syndrome and reactive hypoglycemia while maintaining physiological gastric emptying. This article reviews the technical aspects, physiological rationale, and clinical versatility of DTB, discussing its potential role as an adaptable metabolic procedure for patients with obesity and type 2 diabetes.

Keywords

Duodenal Transit Bipartition, Metabolic Surgery, Transit Bipartition, GLP-1, Bile Acids, FXR, FGF19, TGR5, PYY, Incretins, Type 2 Diabetes, Obesity

1. Introduction

Obesity and type 2 diabetes mellitus (T2DM) represent two of the greatest metabolic epidemics of the 21st century. According to the World Health Organization and the International Diabetes Federation, the prevalence of these diseases continues to increase rapidly across virtually all continents, imposing a significant impact on morbidity, mortality, and healthcare system costs. Obesity is no longer regarded merely as excess body fat but is now recognized as a complex metabolic disease characterized by hormonal, inflammatory, and neuroendocrine alterations that promote insulin resistance, pancreatic beta-cell dysfunction, and progression of type 2 diabetes [1]-[3].

In this context, bariatric and metabolic surgery has become established as the most effective treatment for severe obesity and for the control of type 2 diabetes, yielding superior outcomes compared with intensive medical therapy alone [1] [2] [4]. Several studies have demonstrated that the benefits of these operations extend beyond simple weight loss, involving profound hormonal and metabolic changes resulting from the reorganization of gastrointestinal transit [1] [2] [4].

Traditionally, the metabolic improvement observed after bariatric procedures was believed to be an exclusive consequence of weight loss. However, clinical observations have shown that some patients experience significant glycemic improvement within days of surgery, before substantial weight loss occurs [1] [2]. This phenomenon has prompted intensive investigation into the hormonal, neural, and metabolic mechanisms triggered by the anatomical modifications of the digestive tract.

Among these mechanisms, the most notable include increased secretion of intestinal hormones, particularly glucagon-like peptide-1 (GLP-1) and peptide YY (PYY), as well as alterations in the enterohepatic circulation of bile acids, with consequent activation of metabolic receptors such as the farnesoid X receptor (FXR) and the G protein-coupled bile acid receptor known as TGR5 [5]-[10]. The integrated activation of these pathways may promote improved pancreatic insulin secretion, reduced glucagon secretion, increased satiety, modulation of energy expenditure, and improved glycemic homeostasis [5] [6] [8]-[10].

It was within this physiological context that the classic concept of transit bipartition emerged. Santoro originally proposed transit bipartition applied to the gastric antrum, via a pre-pyloric gastroileostomy, allowing a portion of the food to reach the distal intestine early without completely excluding gastroduodenal transit [11] [12].

Subsequently, this concept was expanded by proposing transit bipartition performed directly on the duodenum, through a post-pyloric duodenoileal anastomosis. This modification preserves the pylorus and gastroduodenal continuity, maintaining a physiological transit pathway while simultaneously anticipating the contact of part of the nutrients with the distal intestine via a post-pyloric anastomosis [13]. Furthermore, this configuration broadens the technical possibilities of this operation, allowing different surgical combinations tailored to the anatomical and metabolic characteristics of each patient, without technically distorting the technical rationale of Duodenal Transit Bipartition originally proposed [13]-[16]. The first Duodenal Transit Bipartition was performed by De Melo in 2006, and the long-term results were recently published in a case report [13].

2. Technical Aspects

Duodenal Transit Bipartition (DTB) consists of creating an anastomosis between the duodenum and a distal intestinal segment (ileum or distal jejunum), preserving the natural continuity of the gastrointestinal tract [13]. Thus, two alimentary pathways coexist: the physiological route through the duodenum and proximal jejunum, and a second route that directs part of the duodenal content early to the

distal intestine.

One of the main features of DTB is its high technical versatility. Currently, DTB can be performed in different configurations (**Figure 1**):

- Isolated Duodenal Transit Bipartition;
- Duodenal Transit Bipartition combined with laparoscopic Sleeve Gastrectomy (Classic Model);
- Duodenal Transit Bipartition combined with Endoscopic Sleeve Gastroplasty (ESG);
- Duodenal Transit Bipartition combined with a proportional gastric sleeve.

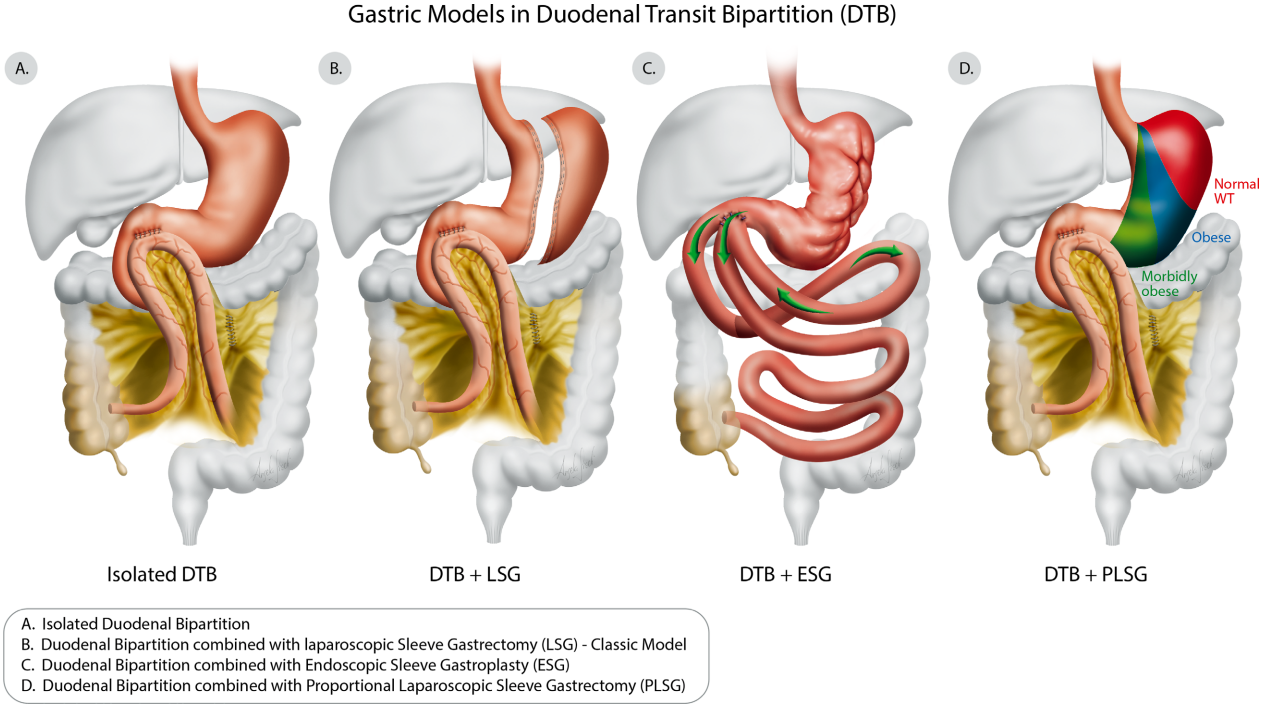

Figure 1. Different configurations for DTB.

Isolated DTB preserves the stomach, concentrating the intervention on the intestinal component. This configuration may be particularly relevant for studying the metabolic effects resulting from intestinal redirection without the interference of an associated gastric resection [13] [16]. Furthermore, isolated bipartitions can be used as a first step in patients with severe obesity and/or intraoperative technical difficulties. In addition, there are already publications reporting their use in lean patients and in patients with overweight or mild obesity with type 2 diabetes [13] [16]-[19].

The association with laparoscopic Sleeve Gastrectomy adds a gastric restrictive and hormonal component to the procedure. Sleeve Gastrectomy reduces gastric volume, modifies gastric emptying, and alters the secretion of gastrointestinal hormones. Studies have shown that the metabolic effects of Sleeve Gastrectomy do not depend solely on dietary restriction, but also involve modifications in bile acids, intestinal signaling, and FXR activation [9] [14]. This model, Sleeve Gas-

trectomy with Duodenal Transit Bipartition, represents the classic model. Probably, when we add a sleeve to Duodenal Transit Bipartition, we have two metabolic mechanisms ("dual incretin effect") acting in conjunction: the sleeve (INTACT), which by itself promotes metabolic stimuli as described above, and the duodenoileal anastomosis, directing duodenal content to the distal intestine early [14] [20].

The combination of DTB with Endoscopic Sleeve Gastroplasty represents a hybrid alternative, in which the gastric component is performed endoscopically, while the intestinal bipartition is constructed surgically via laparoscopy. This configuration seeks to associate gastric volume reduction without gastric resection with the metabolic stimulus resulting from the early arrival of nutrients and digestive secretions to the distal intestine [15].

The association with a proportional gastric sleeve allows selective reduction of the gastric region, preserving most of the stomach and maintaining the pylorus. This alternative may be considered in individualization strategies in which a limited gastric component is added to the intestinal procedure according to the specific characteristics of each patient, including BMI [21]. The most studied Duodenal Transit Bipartition currently is the one that adds Laparoscopic Sleeve Gastrectomy; the remaining models represent alternative models of this procedure. Since the focus is to describe the versatile concept of DTB, we will not delve into the technical details of each cited model.

Furthermore, the anastomosis can be created using different technologies (**Figure 2**):

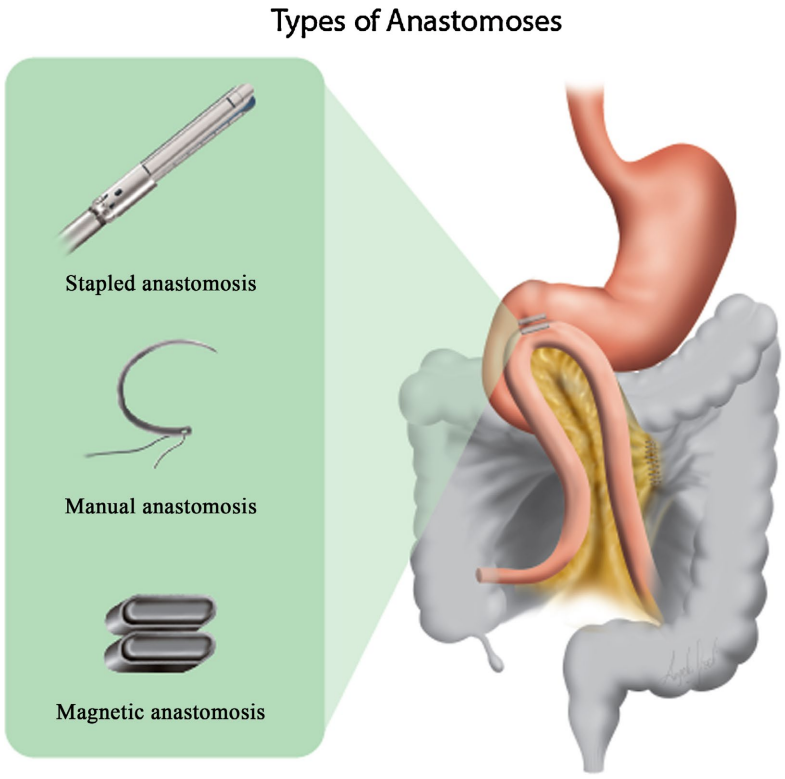

Figure 2. Types of anastomoses.

- Manual laparoscopic anastomosis;
- Stapled laparoscopic anastomosis;
- Magnetic anastomosis.

Manual anastomosis can be performed using intracorporeal suture, allowing direct control of the diameter, orientation, and length of the duodenoenteric communication. However, it requires advanced laparoscopic suturing skills and adequate mobilization of the involved segments [13] [16].

Stapled laparoscopic anastomosis uses linear staplers to create the communication between the duodenum and the distal intestine, followed by closure of the common enterotomy. This approach may provide standardization of anastomotic length and greater speed of execution, depending on the team's experience [14] [15].

Magnetic anastomosis in metabolic surgery, proposed by Gagner and Torres, represents a technological alternative based on progressive compression between magnetic devices positioned in the intestinal segments to be joined. Controlled compression promotes localized tissue necrosis and the formation of a communication between the loops. The magnets add technology and safety to the procedure [22] [23].

Another aspect of the technique proposed is the possibility of performing the anastomosis at different segments of the duodenum (**Figure 3**):

- First portion of the duodenum (D1);
- Second portion of the duodenum (D2);
- Third portion of the duodenum (D3).

In classic Duodenal Transit Bipartition, the anastomosis is performed on the first portion of the duodenum, and it is the most studied model. The other options

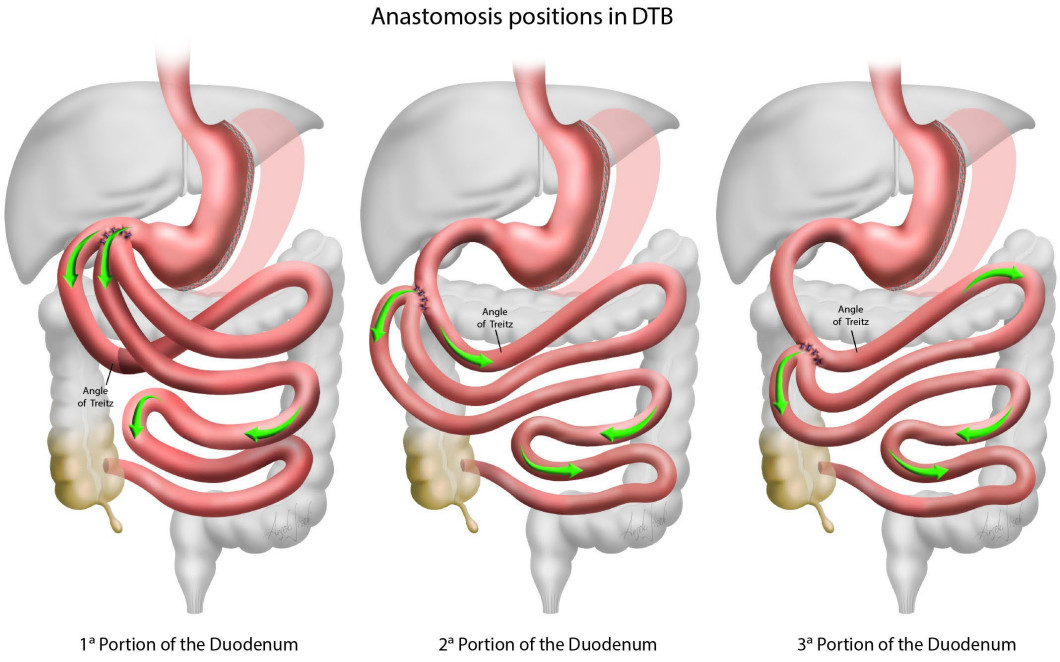

Figure 3. Anastomosis positions in DTB.

for the location of the duodenal anastomosis are merely adaptations of the classic Duodenal Transit Bipartition [13]-[17] [22] [23].

The duodenum is a single, continuous organ, constituting the first part of the small intestine, and is divided anatomically into four portions only to facilitate its description. These portions are not separate organs; therefore, the bile released into the second portion becomes part of the luminal content of the duodenum and may distribute throughout the organ according to motility, content mixing, and pressure gradients.

Although biliopancreatic secretions are released into the second duodenal portion, the duodenum exhibits complex motility, consisting of segmental contractions, anterograde peristaltic waves, and waves propagating in a retrograde direction. Castedal, Björnsson and Abrahamsson found that between 40% and 50% of the pressure waves recorded in the duodenal region adjacent to the pylorus (D1, D2, D3) show retrograde propagation during the postprandial period [24].

Manometric studies in fasting healthy individuals have demonstrated a high proportion of retrograde contractions in the proximal duodenum (85%), especially in the region immediately distal to the pylorus and during the final phase of the migrating motor complex [24] [25]. The authors described this physiological sequence as a kind of duodenal "retroperistaltic pump", related to the proximal movement of duodenal content [25].

These motor patterns promote mixing and intraluminal redistribution of chyme with bile and pancreatic juice, displacing this duodenal content in a proximal direction, *i.e.*, toward the first portion of the duodenum [24]-[26]. Despite the evidence of the presence of bile throughout the duodenum, we still do not have data quantifying the concentration of bile acids in the common channel after performing a transit bipartition in any duodenal portion.

This chyme with bile has metabolic importance, and we will address this topic in the section: Role of Bile Acids in DTB.

Although most Duodenal Transit Bipartitions are classically performed on the first portion of the duodenum, due to the technical and metabolic rationale, duodenal transit bipartition can be performed on other duodenal segments in special surgical situations, in the presence of intraoperative technical difficulties, revisional surgeries or according to the surgeons' experience [14] [16] [27]-[29]. The selection of the anastomosis site in duodenal transit bipartition should consider the patient's individual anatomy, duodenal mobility, proximity to biliary and pancreatic structures, the presence of adhesions or previous operations, and the technical safety of dissection. Anatomical flexibility may expand the possibilities for using the Duodenal Transit Bipartition concept, but each configuration requires specific assessment of feasibility and safety. Importantly, although DTB is an anatomically versatile procedure, the technical and metabolic rationale proposed by De Melo is unique: to create a post-pyloric anastomosis in the duodenum (any portion) applying the classic concept of transit bipartition (Santoro) for the purpose of obtaining incretin stimulation in the distal intestine without the need for duodenal exclusion

[17]. We clarify that the evidence comparing the anastomosis sites D1, D2, and D3 regarding metabolic outcomes and safety is limited; and duodenal motility findings alone may not establish equivalent clinical effects among the sites.

Regarding intestinal transit reconstruction, Duodenal Transit Bipartition can be performed (**Figure 4**):

- In Roux-en-Y;
- In one anastomosis.

Duodenal Transit Bipartitions are generally performed as one anastomosis; however, Roux-en-Y configurations have been published in the past. In **Figure 5**, we summarize the concept of the versatility of Duodenal Transit Bipartition.

The anastomosis in Duodenal Transit Bipartition can be performed in different intestinal segments (**Figure 4**) [14]:

- Duodenojejunal;
- Duodenoileal.

The choice of intestinal segments can be made based on specific characteristics of each patient, such as extremes of age, bowel frequency, and autoimmune disease, aiming at patient safety [14].

It is important to clarify that the specific results of the configuration may vary according to the gastric procedure, the selection of the intestinal loop, the anastomosis technique, and patient selection.

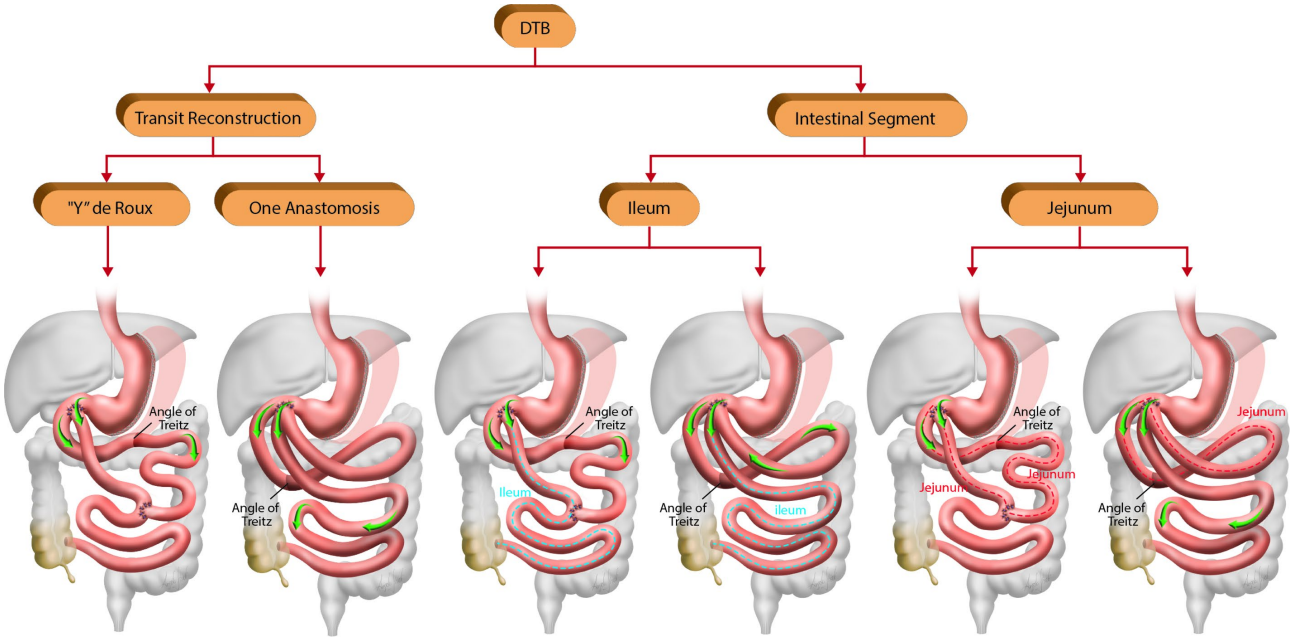

Figure 4. Diagram of DTB.

3. Physiological Basis in Metabolic Procedures: Incretin and Bile Acid Signaling

In metabolic disease, GIP generally loses its incretin function (GIP RESISTANCE), despite being at normal or even elevated levels, whereas GLP-1 is

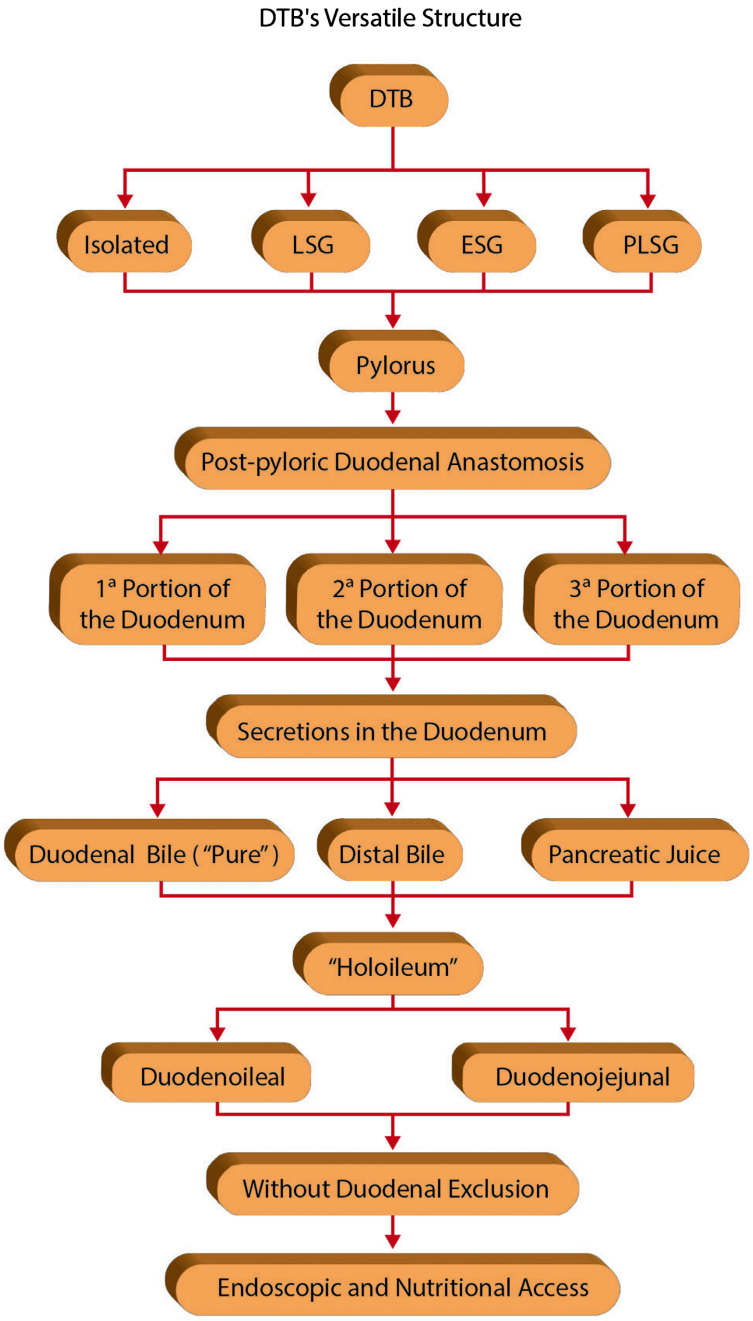

Figure 5. DTB's versatile structure.

usually found at low levels but retains its incretin function. Hypothetically, the recovery of GLP-1 production after metabolic surgeries appears to restore the incretin function of GIP, and they begin to act together again in the control of metabolic disease [14] [30]. Understanding the physiological mechanisms responsible for the benefits of metabolic surgery represents one of the main fields of investi-

gation in the specialty. The results observed after different procedures demonstrate that the gastrointestinal tract acts as an important endocrine organ, capable of regulating glycemia, satiety, energy metabolism, and communication between the intestine, pancreas, liver, adipose tissue, and the central nervous system [5] [6] [8].

Intestinal hormones are released in response to the presence, composition, and speed of arrival of nutrients in the intestinal lumen. Among the main mediators related to the effects of metabolic surgery are GLP-1 and PYY. Both are produced predominantly by the enteroendocrine L cells, distributed along the intestine and present in greater density in the distal ileum and colon [5]-[7].

Although PYY is often discussed together with incretins due to its simultaneous secretion by L cells and its participation in the postprandial response, the term "incretin effect" refers more strictly to the increase in insulin secretion produced by intestinal hormones after oral glucose ingestion. In this context, GLP-1 and glucose-dependent insulinotropic polypeptide (GIP) constitute the main classic incretin hormones. PYY acts predominantly on the regulation of satiety, gastrointestinal motility, and food intake [5]-[7].

3.1. GLP-1

GLP-1 is derived from the processing of proglucagon in intestinal L cells and is released after food ingestion, particularly carbohydrates and lipids. After secretion, it is rapidly degraded by the enzyme dipeptidyl peptidase-4, which limits its plasma half-life. Nevertheless, it exerts relevant metabolic effects through endocrine, paracrine, and neural mechanisms [5] [6].

GLP-1 has multiple physiological actions:

- Stimulates insulin secretion in a glucose-dependent manner;
- Reduces inappropriate glucagon secretion;
- Contributes to decreased hepatic glucose production;
- Slows gastric emptying;
- Increases satiety;
- Reduces food intake;
- May improve pancreatic beta-cell function;
- Participates in the regulation of energy metabolism [5] [6].

Glucose dependence is an important feature of GLP-1's insulinotropic action. Its ability to stimulate insulin secretion is greater when blood glucose is elevated and decreases as glucose approaches normal levels, reducing the risk of hypoglycemia when the system acts in isolation [5].

In type 2 diabetes, the incretin response is impaired. Although GLP-1 secretion may vary among patients, the overall action of the incretin system is often insufficient to compensate for insulin resistance and the progressive deterioration of beta-cell function. Pharmacological amplification of this pathway, through GLP-1 receptor agonists, has demonstrated that its activation can reduce blood glucose, promote weight loss, and improve various metabolic parameters [5].

In operations that anticipate the contact of nutrients with the distal intestine, the more rapid exposure of L cells to alimentary content may produce an increased postprandial GLP-1 response, and this is often related to the rapid improvement in glycemic control observed after metabolic procedures, although clinical outcomes result from the interaction of multiple pathways, not a single hormone [1] [2] [5] [6].

In Duodenal Transit Bipartition, part of the gastrointestinal content is directed early to the distal intestine through the post-pyloric anastomosis. This configuration may promote early exposure of distal enteroendocrine cells to nutrients and, consequently, may increase postprandial GLP-1 secretion. Probably the preservation of the pylorus may add a relevant physiological feature, controlling gastric emptying, the release of alimentary content into the distal intestine, and reducing the risks of diarrhea, dumping, and reactive hypoglycemia [14] [31] [32].

3.2. PYY

PYY is a peptide hormone produced mainly by the L cells of the ileum and colon. Its concentration increases after meals in proportion to the caloric load and nutrient composition. After secretion, part of PYY is converted to PYY3-36, a form that exerts an important anorexigenic action through Y2 receptors located in the central nervous system and vagal circuits [7].

The main effects attributed to PYY include:

- Reduced appetite;
- Increased satiety;
- Decreased food intake;
- Modulation of gastrointestinal motility;
- Slowing of intestinal transit;
- Participation in the so-called ileal brake;
- Possible contribution to improved insulin sensitivity [7].

The ileal brake corresponds to a set of responses triggered by the presence of nutrients in the distal intestine. These responses reduce proximal gastrointestinal motility, prolong digestion time, increase satiety, and limit subsequent food intake. PYY acts together with GLP-1 and other mediators in this mechanism [31].

After bariatric and metabolic procedures that accelerate the arrival of nutrients to the distal intestine, postprandial PYY concentrations often increase. This elevation may contribute to the spontaneous reduction in food intake and the maintenance of weight loss [1] [5]-[7].

In DTB, the duodenoileal anastomosis creates a short route between the duodenum and the distal intestine. Part of the nutrients may reach regions with a high density of L cells early, stimulating PYY secretion. The combined action of PYY and GLP-1 may increase satiety, reduce food intake, and modulate gastrointestinal transit [31].

Although both are released by L cells, GLP-1 and PYY exert partially distinct and complementary functions. GLP-1 plays a strong role in regulating insulin and

glucagon secretion, whereas PYY acts more predominantly on satiety and gastrointestinal motility. Their simultaneous release may produce an integrated response between glycemic control and eating behavior [5]-[7].

3.3. Bile Acids and FGF19

Bile acids were traditionally understood as detergent substances responsible for the emulsification and absorption of fats and fat-soluble vitamins. However, contemporary knowledge demonstrates that they also act as signaling molecules capable of regulating glucose, lipid, and energy metabolism through nuclear and membrane receptors [8]-[10] [31] [33].

Primary bile acids are synthesized in the liver from cholesterol, conjugated, and secreted into bile. After food ingestion, gallbladder contraction releases bile into the duodenum. Bile acids participate in lipid digestion and are subsequently reabsorbed, mainly in the terminal ileum, returning to the liver via the portal circulation. This process constitutes the enterohepatic circulation.

In the intestine, bile acids can be transformed by the microbiota into secondary bile acids. The composition of the bile acid pool influences its capacity to activate metabolic receptors, particularly FXR and TGR5 [8].

3.4. FXR-FGF19 Pathway

FXR is a nuclear receptor activated by bile acids and expressed mainly in the liver and intestine. In the ileal enterocyte, FXR activation stimulates the expression and secretion of Fibroblast Growth Factor 19 (FGF19) [8] [10].

In experimental models, the corresponding hormone is termed FGF15, whereas in humans, the equivalent mediator is FGF19. For this reason, the literature often uses the term FGF15/19 when describing this pathway [10].

After being produced in the intestine, FGF19 reaches the liver through the portal circulation. In hepatic tissue, it binds to receptor complexes that include FGFR4 and the β-Klotho coreceptor. This signaling reduces the expression of the enzyme cholesterol 7-alpha-hydroxylase, encoded by the CYP7A1 gene, which is responsible for a rate-limiting step in bile acid synthesis [10].

Thus, the FXR-FGF19 pathway establishes a feedback mechanism: bile acids reaching the ileum activate FXR, increase FGF19 production, and subsequently reduce hepatic synthesis of new bile acids.

Beyond the control of bile acid synthesis, FGF19 participates in the regulation of systemic metabolism. Among its potential actions are:

- Modulation of hepatic glucose production;
- Influence on gluconeogenesis;
- Participation in glycogen synthesis;
- Regulation of lipid metabolism;
- Modulation of bile acid synthesis;
- Possible improvement in insulin sensitivity;
- Participation in energy balance [8] [10].

The relationship between FGF19 and hepatic metabolism is complex. Experimental studies suggest that its signaling may reduce hepatic glucose production and improve lipid parameters. However, the clinical response depends on the physiological context, the composition of the bile acid pool, receptor integrity, hepatic function, and interaction with other intestinal hormones [8] [10].

Bariatric and metabolic procedures can modify the concentration, composition, and flow of bile acids. These alterations may influence FXR activation and FGF19 production. Experimental studies have identified FXR as an important mediator of the effects of Sleeve Gastrectomy, demonstrating that bile acid signaling participates in the metabolic outcomes of this operation [9].

3.5. TGR5 Receptor

TGR5, also known as G protein-coupled bile acid receptor 1, is a membrane receptor activated by bile acids. It is present in different tissues, including enteroendocrine cells, macrophages, adipose tissue, muscle, and structures of the nervous system [8] [31].

TGR5 activation may promote:

- Increased GLP-1 secretion by enteroendocrine cells;
- Modulation of energy expenditure;
- Influence on mitochondrial function;
- Regulation of inflammatory responses;
- Participation in glucose metabolism;
- Modulation of insulin sensitivity [8].

In L cells, TGR5 activation by bile acids increases intracellular cyclic adenosine monophosphate production and favors GLP-1 secretion. This mechanism establishes a direct connection between bile acid flow and the incretin system [8].

Thus, the arrival of bile acids at the distal intestine may stimulate GLP-1 secretion through at least two complementary pathways: the contact of nutrients with L cells and the activation of TGR5 by bile acids. The interaction between these pathways may contribute to the metabolic improvement observed after operations that modify intestinal transit.

FXR and TGR5 should not be considered isolated pathways. Both respond to the composition and distribution of bile acids, but they exert different functions. FXR acts as a nuclear receptor, regulating gene transcription and stimulating FGF19 production. TGR5 acts as a membrane receptor and triggers rapid cellular responses, including GLP-1 secretion [8].

4. Role of Bile Acids in Duodenal Transit Bipartition

Duodenal Transit Bipartition has a particular anatomical and physiological characteristic. Because the anastomosis is performed in a post-pyloric position, the content originating from the duodenum can reach the distal intestine early, accompanied by bile and pancreatic secretions [14] [31].

In normal gastrointestinal anatomy, bile and pancreatic juice are released into

the duodenum and progressively mix with the food bolus during its passage through the proximal intestine. In DTB, a proportion of this duodenal mixture may be diverted directly to a more distal segment through the anastomosis.

Thus, the distal intestine may receive early a combination of:

- Partially processed nutrients;
- Bile acids;
- Pancreatic juice;
- Duodenal and intestinal secretions;
- Initial products of carbohydrate, protein, and lipid digestion.

This combination, reaching the distal intestine early, appears to confer metabolic benefits in metabolic procedures, and there are three hypotheses that attempt to justify these benefits: the foregut hypothesis, the hindgut hypothesis, and the Holoileum hypothesis. We will briefly discuss each of them.

The foregut hypothesis proposes that the exclusion of the duodenum and proximal jejunum from nutrient transit is essential for the metabolic improvements observed after gastric bypass procedures. This theory suggests that the passage of nutrients through the proximal small intestine triggers the secretion of anti-incretin factors that promote insulin resistance and impair glucose metabolism [34].

The hindgut hypothesis posits that the metabolic benefits of bariatric surgery result primarily from enhanced and accelerated delivery of nutrients to the distal small intestine. This early ileal nutrient exposure stimulates L-cells to secrete increased amounts of GLP-1, PYY and oxyntomodulin, which have profound effects on glucose metabolism and appetite regulation. GLP-1 enhances glucose-dependent insulin secretion, suppresses glucagon release, delays gastric emptying, and promotes satiety through central nervous system effects. PYY contributes to the ileal brake mechanism and reduces food intake. The hindgut hypothesis is supported by ileal transposition experiments, where surgical repositioning of a segment of distal ileum to the proximal jejunum resulted in improved glucose tolerance and elevated GLP-1 levels without any duodenal exclusion. Furthermore, the metabolic improvements observed after SG, which does not alter intestinal anatomy but accelerates gastric emptying and enhances distal nutrient delivery, provide additional support for the primacy of hindgut mechanisms [34].

Holoileum hypothesis—Building upon and extending both the foregut and hindgut paradigms, Santoro proposed the Holoileum hypothesis, which introduces a fundamentally different perspective on the mechanisms of metabolic surgery. The term "holoileum" refers to the ileum (as a common channel) functioning as a complete endocrine organ, when exposed to both pancreatic and biliary secretions mixed with partially digested food, leading to incretin effects associated with other favorable metabolic elements [34] [35].

This early exposure may modify enteroendocrine signaling and the enterohepatic circulation of bile acids. Theoretically, greater contact of the ileum with bile acids may favor ileal FXR activation, increase FGF19 production, and stimulate TGR5 in L cells, potentiating GLP-1 secretion [8]-[10] [31].

Consequently, the following may occur:

- Increased intestinal FGF19 production;
- Greater postprandial GLP-1 secretion;
- Increased PYY secretion;
- Improved glucose-dependent insulinotropic response;
- Reduced inappropriate glucagon secretion;
- Increased satiety;
- Possible improvement in insulin sensitivity;
- Modulation of hepatic glucose production;
- Improved lipid metabolism.

The metabolic effects mentioned above are anticipated in metabolic surgeries; however, they have not yet been directly measured in patients undergoing DTB.

A physiological feature in DTB is that part of the chyme with duodenal bile ("pure bile") may reach the distal intestine early without traveling the entire proximal jejunal route. Didactically, De Melo calls "pure bile" the bile that is produced and released directly into the duodenum; however, we know that this bile is associated with other duodenal secretions. We cannot affirm it, but there are some experimental studies that present interesting evidence of the metabolic effect of this bile, mainly when diverted to the distal intestine. In these studies, the simple direct diversion of this bile to more distal portions of the intestine appears to produce metabolic effects similar to those found in gastric bypass; however, we still need more robust evidence to confirm these effects [36]-[38]. This configuration may modify both the location and timing of the exposure of intestinal receptors to bile acids.

5. Discussion

Duodenal Transit Bipartition represents an expansion of the bipartition concept originally proposed by Santoro [11] [12]. By shifting the anastomosis to a postpyloric position, the technical possibilities of the procedure while preserving the fundamental principle of maintaining a physiological alimentary pathway associated with a second route directed to the distal intestine [13].

The procedure preserves the pylorus, maintains gastroduodenal continuity, and does not promote complete exclusion of the duodenum or proximal intestine. Simultaneously, it provides early exposure of the distal intestine to nutrients and biliopancreatic secretions.

This configuration differentiates DTB from operations involving anatomical exclusion of digestive segments. The preservation of continuity may facilitate endoscopic access to the stomach, duodenum, and the duodenal papilla region, although the ease of access depends on the final anatomy, the technique used, and the endoscopist's experience.

Another important differential is its versatility. While some operations generally have a relatively standardized configuration, Duodenal Transit Bipartition can be adapted to the patient's clinical profile, anatomy, and intraoperative technical

difficulties.

This individualization and versatility may primarily involve:

- Different gastric components;
- Different anastomotic construction techniques;
- Different anastomotic locations in the duodenum;
- Different intestinal segments (ileum/jejunum);
- Two types of intestinal transit reconstruction.

From a metabolic perspective, the combination of early L-cell exposure to nutrients and the possible modification of bile acid signaling constitutes a central hypothesis for explaining the effects of the technique. Increased GLP-1 and PYY secretion may contribute to improved glycemia, increased satiety, and reduced food intake [5]-[7].

In parallel, the early arrival of bile acids at the ileum may activate the FXR-FGF19 and TGR5-GLP-1 pathways, influencing hepatic metabolism, hormonal secretion, and energy balance [8]-[10]. These mechanisms are biologically plausible and are supported by studies on bile acid physiology and other metabolic operations [31] [33] [35].

It would not be appropriate to attribute the metabolic effects of DTB, or other metabolic surgical procedures, exclusively to a single mechanism. The metabolic benefit of these metabolic procedures likely derives primarily from the interaction between anatomical alterations, nutrient flow, intestinal signaling, and bile acids, and secondarily from caloric reduction and weight loss [14].

Preservation of the pylorus in DTB may represent a physiological advantage by maintaining part of the natural control of gastric emptying and the release of content into the duodenum. This feature may reduce the speed of arrival of large hyperosmolar volumes to the intestine compared to reconstructions without pyloric control [14] [32].

Another relevant point is the balance between metabolic efficacy and nutritional safety. The maintenance of a physiological pathway may theoretically preserve part of the proximal absorption of iron, calcium, and other micronutrients. However, the presence of this pathway may not eliminate the possibility of nutritional deficiencies, especially when the procedure is combined with gastric reduction or a shorter common channel, a fact that may occur in other metabolic surgical procedures.

The long-term follow-up report of isolated DTB provides initial evidence regarding the possible durability of the concept, but does not replace prospective studies with larger numbers of patients, comparator groups, and standardized assessment of safety, efficacy, and quality of life [13].

Thus, DTB may be understood not as a single rigid operation, but as a technical and metabolic concept that allows different configurations. Perhaps its main strength is precisely the possibility of personalization. However, this same diversity requires rigor in the description of methods, patient selection, and interpretation of results.

6. Conclusions

Duodenal Transit Bipartition constitutes an expansion of the classic concept of transit bipartition by shifting the anastomosis to the duodenum in a post-pyloric position [11]-[13].

Its main characteristic is the high technical versatility, allowing different combinations with gastric procedures, distinct methods of anastomotic construction, and different locations of the duodenal anastomosis. This flexibility theoretically enables treatment individualization according to the anatomical, clinical, and metabolic characteristics of each patient.

From a physiological standpoint, the preservation of gastroduodenal transit associated with early stimulation of the distal intestine may favor increased GLP-1 and PYY secretion [5]-[7]. Furthermore, the early arrival of bile acids and pancreatic secretions to the distal intestine may modify the activation of the FXR-FGF19 and TGR5-GLP-1 pathways, recognized as important regulators of glycemic homeostasis, lipid metabolism, and energy balance [8]-[10] [31] [33] [35].

Thus, the concept proposed by De Melo constitutes a versatile surgical procedure that is potentially capable of offering different therapeutic options for patients with obesity and type 2 diabetes. Although these hypotheses are grounded in contemporary knowledge of intestinal physiology, prospective studies are needed to define safety, efficacy, and long-term metabolic and nutritional outcomes.

Author Contributions

Conceptualization, P.R.R.E.M.; writing—original draft preparation, D.S.K. and P.R. R.E.M.; writing—review and editing, C.A.S.M., P.N., E.P.G., G.U.B., M.A.A., R.J.S.R., L.A.V.A., V.A.S.R., H.O.J., J.J.W.J., R.O.F., M.R.R.J., R.Z., and A.T. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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