

# World Journal of *Diabetes*

*World J Diabetes* 2022 March 15; 13(3): 129-281



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The primary aim of *World Journal of Diabetes* (*WJD*, *World J Diabetes*) is to provide scholars and readers from various fields of diabetes with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

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**INDEXING/ABSTRACTING**

The *WJD* is now abstracted and indexed in Science Citation Index Expanded (SCIE, also known as SciSearch®), Current Contents/Clinical Medicine, Journal Citation Reports/Science Edition, PubMed, and PubMed Central. The 2021 Edition of Journal Citation Reports® cites the 2020 impact factor (IF) for *WJD* as 3.763; IF without journal self cites: 3.684; 5-year IF: 7.348; Journal Citation Indicator: 0.64; Ranking: 80 among 145 journals in endocrinology and metabolism; and Quartile category: Q3.

**RESPONSIBLE EDITORS FOR THIS ISSUE**

Production Editor: Rui-Rui Wu, Production Department Director: Xu Guo, Editorial Office Director: Jia-Ping Yan.

**NAME OF JOURNAL**

*World Journal of Diabetes*

**ISSN**

ISSN 1948-9358 (online)

**LAUNCH DATE**

June 15, 2010

**FREQUENCY**

Monthly

**EDITORS-IN-CHIEF**

Lu Cai, Md. Shahidul Islam, Jian-Bo Xiao, Manfredi Rizzo, Michael Horowitz

**EDITORIAL BOARD MEMBERS**

<https://www.wjnet.com/1948-9358/editorialboard.htm>

**PUBLICATION DATE**

March 15, 2022

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<https://www.wjnet.com/bpg/GerInfo/288>

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<https://www.wjnet.com/bpg/gerinfo/242>

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## Beyond diabetes remission a step further: Post bariatric surgery hypoglycemia

Devraj Lath, Kripa Elizabeth Cherian, Thomas Vizhalil Paul, Nitin Kapoor

**Specialty type:** Endocrinology and metabolism

**Provenance and peer review:**

Invited article; Externally peer reviewed.

**Peer-review model:** Single blind

**Peer-review report's scientific quality classification**

Grade A (Excellent): 0  
Grade B (Very good): B, B  
Grade C (Good): C, C, C  
Grade D (Fair): 0  
Grade E (Poor): 0

**P-Reviewer:** Belosludtseva NV, Gupta R, Liu C, Seetharaman RV, Shao JQ

**Received:** September 24, 2021

**Peer-review started:** September 24, 2021

**First decision:** January 12, 2022

**Revised:** January 21, 2022

**Accepted:** February 23, 2022

**Article in press:** February 23, 2022

**Published online:** March 15, 2022



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### Abstract

Postbariatric hypoglycemia is a rare but increasingly recognized complication of bariatric surgery, with significant associated morbidity, and many patients often require multimodal treatment. A mixed meal challenge test is often helpful to diagnose this condition. This manuscript highlights the underlying mechanisms that lead to this condition and the novel emerging therapeutic targets that target these mechanisms.

**Key Words:** Postbariatric hypoglycemia; Hyperinsulinemic hypoglycemia; Avexotide; GLP-1 antagonist; Obesity

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**Core Tip:** Postbariatric hypoglycemia is an uncommon complication presenting months to years after bariatric surgery (mostly in Roux-en-Y gastric bypasses) as postprandial hyperinsulinemic hypoglycaemia occurring 1-3 h after meals, and the associated neuroglycopenic symptoms can be incapacitating. Medical nutrition therapy forms the foundation of management, with pharmacotherapy and surgical interventions available for those who do not respond. An increased understanding of the implicated mechanisms has led to the development of targeted agents like avexotide, which has demonstrated good efficacy in a Phase 2 clinical trial (PREVENT) recently.

**Citation:** Lath D, Cherian KE, Paul TV, Kapoor N. Beyond diabetes remission a step further: Post bariatric surgery hypoglycemia. *World J Diabetes* 2022; 13(3): 278-281

**URL:** <https://www.wjgnet.com/1948-9358/full/v13/i3/278.htm>

**DOI:** <https://dx.doi.org/10.4239/wjd.v13.i3.278>

## TO THE EDITOR

We read with interest the review by Jin *et al*[1], who discussed the potential mechanisms underlying the remarkable efficacy of bariatric surgery in inducing remission of type 2 diabetes mellitus, ranging from 33% in adjustable gastric banding to up to 95% in biliopancreatic diversion. In a recent meta-analysis involving 174772 patients compared in 16 cohort studies and 1 controlled trial, bariatric surgery was associated with a reduction in the risk of all-cause mortality by 49.2% and an increased median life expectancy of 6.1 years. These benefits were even greater among those diagnosed with type 2 diabetes mellitus[2].

Postbariatric hypoglycaemia (PBH) is an infrequent but potentially debilitating complication, with a multicenter registry-based study in Spain having reported 22 patients developing hypoglycemia following 4645 interventions, amounting to an incidence rate of 0.47%[3]. In another study using registry data, 5040 Swedish patients that underwent Roux-en-Y gastric bypass (RYGB) were matched with 10 non-surgical controls each, with no preoperative difference in the frequency of hypoglycemia or potentially related diagnoses such as confusion, seizures or syncope[4]. Following gastric bypass, 0.2% of the post-gastric bypass cohort were admitted for hypoglycemia *vs* 0.04% of the general population. Although the overall incidence is variable, these patients were at a two- to sevenfold increased risk of hypoglycemia and related diagnoses when compared to their controls. The authors also found that there was no significant increase in the risk of postbariatric hypoglycemia or related diagnoses among patients undergoing restrictive procedures, namely vertical banded gastroplasty (4366) and gastric banding (2917) when matched with controls. Patients without diabetes especially are at an increased risk of hypoglycemia following bariatric surgery *vs* those managed medically[5]. Greater frequencies of hypoglycemia (32.6% and 22.6%) are observed in gastric bypass (GBP) and sleeve gastrectomy patients subjected to a two-hour oral glucose tolerance test (OGTT)[6], with much lower rates (2.3%)[6] reported in those undergoing gastric banding[5-6]. In another study by Tzovaras *et al*[7], 29% experienced definite dumping syndrome while another 16% had symptoms suggestive of the same.

Patients undergoing bariatric surgery (especially RYGB surgery) may develop severe vasomotor symptoms of sweating, dizziness, weakness and flushing, referred to as dumping syndrome. These are attributed to the osmotic effect of rapid food entry into the intestines, release of peptide hormones like vasoactive intestinal peptide, incretins and the enteric neural response. By contrast, the development of symptoms such as confusion, decreased vision, syncope, hunger, behavioural changes, syncope and seizures are suggestive of neuroglycopenia, and these patients are found to have low plasma glucose levels 1-3 h after a meal consistent with reactive hypoglycemia[8]. This occurs months to years after bariatric surgery, and though these phenomena have been classified as early and late dumping syndrome respectively[8], some suggest the term postbariatric hypoglycemia be used instead[8-9] and that the term dumping syndrome be reserved for the vasomotor symptoms caused by rapid gastric emptying, diagnosed by an increase in pulse rate > 10/min and/or a rise in hematocrit by 3% after an OGTT. Apart from the risks of severe hypoglycemia, these patients are also more likely to regain weight due to frequent food intake.

The diagnosis of hypoglycaemia requires the documentation of low plasma glucose during the presence of symptoms and/or signs attributable to hypoglycemia, which are relieved by raising the plasma glucose concentration (known as Whipple's triad)[10]. Postbariatric hypoglycemia following meal intake is caused by postprandial hyperinsulinemia, diagnosed by a mixed meal challenge test (MMCT) demonstrating hypoglycemia (glucose less than 55 mg/dL) accompanied by inappropriately elevated insulin (> 3.0 U/mL) and C-peptide (> 0.6 ng/mL)[9-10]. An important differential is the exclusion of a co-existing insulinoma[11-12] by cross sectional imaging or endoscopic ultrasonography, although these patients generally present with fasting hypoglycemia.

Postprandial hyperinsulinemic hypoglycemia following bariatric surgery was first described by Service *et al*[11] in a series of six patients who presented years after GBP surgery with neuroglycopenic symptoms and were found to have hyperinsulinemic hypoglycaemia. One patient was found to have an insulinoma, and the other five underwent pancreatectomy guided by intra-arterial calcium stimulation tests. Pathological examination showed islet cell hypertrophy and hyperplasia suggestive of nesidioblastosis and it was initially proposed that bypass surgery had resulted in beta cell hyperfunctioning and hyperinsulinemia. However other studies contest this finding[13], and other mechanisms proposed include an enhanced incretin effect[14], abnormal counter-regulatory hormone responses[15], altered enterohepatic circulation of bile acids[16] and changes in the microbiome[17]. The rapid transit of food from the stomach to the intestinal L cells is believed to result in an excessive release of incretins such as gastric inhibitory peptide and glucagon-like peptide 1 (GLP-1) in particular, with greater levels being



observed in symptomatic patients after meals[14].

The management of PBH is complex as its mechanisms remain incompletely understood. The majority of cases exhibiting mild symptoms respond to dietary modification, and medical nutritional therapy (MNT) is the cornerstone of management. The frequent intake of smaller meals comprising carbohydrates with a low glycaemic index helps prevent hypoglycaemia[18], with the intake of meals low in protein and/or high in sugars known to trigger these episodes[19]. Various pharmacological agents have been used with some success for patients who fail MNT, by blunting the inappropriately elevated insulin secretion and ensuing hypoglycemia. These include the alpha-glucosidase inhibitor acarbose, calcium channel antagonists like nifedipine or verapamil, the beta-cell adenosine triphosphate-sensitive potassium channel agonist diazoxide (inhibits insulin secretion by hyperpolarisation) and somatostatin analogues like octreotide[20]. Refractory patients may require a gastrostomy tube placement or a restrictive procedure, with some undergoing partial or total reversal of the bypass [9,20]. Over the years, GLP-1 has become an increasingly attractive target. A recent phase 2 randomised placebo-controlled crossover study (PREVENT) employing the GLP-1 receptor antagonist avexotide [exendin (9-39)] for 28 days showed a significant decrease in the occurrence of hypoglycemia in response to a MMCT requiring rescue as well as on continuous glucose monitoring, with an improved glycemic profile[21]. In another study[22], 12 participants with PBH were randomised to receive either glucagon or a placebo from an artificial pancreas system during meals as guided by a predictive algorithm using continuous glucose monitoring. The patients who received glucagon did not require rescue glucose or develop severe hypoglycemia (< 55 mg/dL), unlike those who received the vehicle, and thus mitigating severe hypoglycemia in PBH.

Elucidation of the other proposed mechanisms may guide the development of other safe and effective therapies for PBH.

## FOOTNOTES

**Author contributions:** Kapoor N conceived of the presented idea and provided critical feedback to the final manuscript; Lath D wrote the manuscript; Cherian K and Paul TV approved the main conceptual ideas and proof outline; all authors provided final edits and approved the manuscript.

**Conflict-of-interest statement:** No conflict of interest.

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**S-Editor:** Wu YXJ

**L-Editor:** A

**P-Editor:** Wu YXJ

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