Abstract

Severe malnutrition following One Anastomosis Gastric Bypass (OAGB) remains a concern. Fifty studies involving 49,991 patients were included in this review. In-hospital treatment for severe malnutrition was needed for 0.9% (n=446) of patients. Biliopancreatic limb (BPL) length was 150cms in five (1.1%) patients, >150cms in 151 (33.9%) and not reported in 290 (65%) patients. OAGB was revised to normal anatomy in 126 (28.2%), sleeve gastrectomy in 46 (10.3%), Roux-en-Y gastric bypass in 41 (9.2%) and shortening of BPL length in 17 (3.8%) patients. 151 (33.8%) patients responded to treatment, ten (2.2%) did not respond and was not reported in 285 (63.9%) patients. Eight (0.02%) deaths were reported. Standardisation of the OAGB technique along with robust prospective data collection is required to understand this serious problem.

Key points

- Malnutrition follow OAGB is a rare but serious complication.
- This review observed diverse operating, management plans, and underreporting.
- An algorithm to adapt was designed when there is an incidence of malnutrition.
- Standardising surgical technique & robust data collection are the recommendations.

Introduction

Metabolic and bariatric surgery (MBS) is an effective treatment option for patients with obesity that leads to a durable weight loss and resolution of associated medical conditions (1)(2).

Annually, over half a million MBS procedures are performed worldwide (3). The three most performed bariatric procedures are Sleeve Gastrectomy (SG), Roux-en-Y Gastric Bypass (RYGB) and One Anastomosis Gastric Bypass (OAGB). Since the technique was first described by Rutledge in 1997, the popularity and acceptance of OAGB has grown worldwide albeit rather slowly. Nonetheless, OAGB was approved by the International Federation for the Surgery of Obesity and Metabolic disorders (IFSO) as a mainstream bariatric procedure in 2017, and more recently by the American Society for Metabolic and Bariatric Surgery (ASMBS) in May 2022 (4)(5).

Currently it is estimated that OAGB accounts for about 10% of all MBS procedures performed worldwide (6). The advantages of OAGB include short operation time, low incidence of perioperative complications, and substantial weight loss with a significant metabolic effect (7). The main reason for a slower acceptance of OAGB is the risk of complications in the long term and the actual lack of data on such outcomes. Long term complications predominantly include anastomotic ulcers, biliary reflux, and protein-energy malnutrition sometimes with excessive weight loss (7). Current evidence suggests that overall, 5% of OAGB patients may develop some complication in the long-term with a reoperation rate of just over 1% (4). Malnutrition and micronutrient deficiencies are a risk after any MBS, and hence patients require close follow up with input from dietitians and life-long supplements (8). However, severe malnutrition that requires in-hospital treatment should be rare and are more often seen after pure malabsorptive procedures such as Biliopancreatic Diversion and Duodenal Switch (BPD/DS) (9)(10).

Malnutrition following OAGB has been reported either as overall protein-energy deficiency or isolated elements such as protein levels (11)(12)(13), vitamin deficiency (11), or anaemia (14)(15). The majority of these patients can be managed with the appropriate dosage of nutritional supplements and close monitoring as per published guidelines (11)(12). However, the risk of severe malnutrition after OAGB that requires in-hospital treatment is not clear. In this systematic review, we aimed to examine the current evidence to understand the incidence, clinical presentation, contributory factors, and management of severe malnutrition following OAGB.

Methods

Literature search and study selection

We followed the Participants, Intervention, Comparison, and Outcome (PICO) framework (16) and the review process was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (17).

Search strategy

A comprehensive electronic literature search was performed on 1st July 2022 using PubMed, Medline, Embase and Science Direct databases. The following keywords were used: *malnutrition* OR *protein calorie deficiency* OR *nutritional deficiency* OR *afferent loop syndrome* AND *mini gastric bypass* OR *loop gastric bypass* OR o*ne-anastomosis gastric bypass* OR *omega loop gastric bypass* OR *MGB* OR *OAGB*. There were no date restrictions.

Selection process

Once duplicates were removed, two authors (NB and GH) independently screened the titles and abstracts, and excluded those that were not relevant to the research question. Full text articles of the remaining studies were obtained and assessed for eligibility as per the inclusion criteria. A summary of the literature search and study selection process is shown in the PRISMA flow chart (Figure 1). Two authors (NB and GH) independently undertook the initial literature search and subsequent study selection process. Any discrepancies were resolved after discussion with the senior author (BM). In addition to the electronic searches, other texts were identified from reference lists and key journals.

Eligibility criteria

Studies involving adults (≥18 years) that developed severe malnutrition after primary or revisional OAGB requiring in hospital treatment either with intravenous nutrient therapy or artificial feeding or surgical intervention were included in this review. Studies that described combined bariatric procedures (e.g., OAGB with gastric band), review articles, conference abstracts, studies not published in English (where translation was not available), and studies with bariatric procedures other than OAGB were excluded from this review.

Study risk of bias assessment

The studies included in the review were assessed for quality with National Institute of Health (NIH) quality assessment tool (18). The review protocol was successfully registered with PROSPERO (National Institute of Health Research and University of York, UK, Number CRD42021226659) (19).

Data extraction and synthesis

Various data were extracted from each text and were collated using Microsoft Excel (Microsoft Corporation, Redmond, WA, USA). Recorded data included patient demographics, surgical technique, post-operative nutritional status, clinical presentation, diagnostic investigations, and interventions for severe malnutrition. Albumin deficiency was graded as being mild (3-3.4grams/decilitre (g/dl)), moderate (2.5-2.9g/dl) or severe (<2.5g/dl). We attempted to contact the authors for clarification of data if needed. When specific data were not available, they were recorded as 'not reported'.

Simple descriptive statistics were employed. Continuous variables are expressed as median (range) and categorical variables as number (percentage). Meta-analysis was not performed due to the heterogeneous nature of studies included in this review.

Results

Initial search identified 1233 articles and of these, 178 articles were excluded after deduplication. Fifty publications were eventually included as shown in table 1. Majority were retrospective studies (n=36), followed by case reports (n=10), case series (n=2), randomised controlled trial (n=1), and letter to the editor (n=1). In total 49,991 patients who underwent OAGB were included, of which 446 (0.9%) patients required in-hospital treatment for severe malnutrition.

Basic demographics, Body Mass Index (BMI) and Comorbidities

Pre-operative demographics were scarcely reported. In the reported 41 patients, the youngest was 22 years and the oldest was 71 years of age with a median of 48.5 years. Gender was reported in 85 patients and of these 75 were female and 10 were male. Median pre-operative BMI in the 44 reported patients was 45.1 kilograms per square metre (kg/m^2) with a range from 33 kg/m^2 to 73 kg/m^2. Pre-operatively, 11 (2.4%) patients were reported to be hypertensive, 16 (3.5%) patients were diabetic, 3 (0.6%) patients were hypothyroid, 14 (3.1%) patients had dyslipidaemia, 9 (1.9%) patients had liver steatosis, and 3 (0.6%) patients had obstructive sleep apnoea. None of the studies reported pre-operative dietary habits. Four patients were reported as smokers and another drank alcohol. Pre-operative nutritional status was reported in 59 (13.2%) patients.

Operative details

Full operative details were seldom reported. Of the 446 patients, 223 (50%) patients had OAGB as a primary bariatric procedure, 38 (8.5%) were revisional and this was not reported in 185 (41.5%) patients. The Bilio-Pancreatic Limb (BPL) length was not reported in 65% (N=290) of the patients. The reported BPL lengths are shown in table 1. In 403 (90.4%) patients the efferent limb length was not reported. Where reported (N=43, 9.6%), the length varied from 80 centimetres (cms) (20) to 520 cms (21). Bougie size was not reported in 348 (78%) patients. Most used bougie size was 36 French (Fr) in 73 (16.3%) patients, followed by 34 Fr in 12 (2.7%) patients, 37 Fr in 9 (2%) patients, 38 Fr and 32 Fr in two (0.4%) patients each. Length of gastric pouch was not reported in 439 (98.4%) patients. For the reported seven (1.6%) patients, a large variation in the length of pouch was noted from 4 cms (22)(23) to 20 cms (24).

Post-operative presentation and investigations

The time of presentation with malnutrition since the initial operation was not reported in 391 (87.7%) patients. In the remaining 55 (12.3%) patients, the median was 14 months (range 1- 84 months). Post-operative BMI was reported for only 35 (7.8%) patients, with a median of 25.1 kg/m^2 (range 15.8 - 42 kg/m^2) but was not reported in 411 patients (92.2%). Total weight loss was again reported in only 13 (2.9%) patients and the median weight loss was 53 kilograms (kgs) (38 - 126 kgs). Three out of the four patients who reported smoking and the one with consumption of alcohol before OAGB continued post-operatively. The BPL length was reported in a total of 156 (35%) patients, of which 151 (96.7%) had BPL of more than 150 cms. Some 117 (26.2%) patients were reported to develop protein energy malnutrition (PEM), whereas 181 (40.6%) patients had exclusive albumin deficiency, 96 (21.5%) patients were found to be anaemic and there was Iron deficiency in 61 (13.7%) patients. Forty-five of the 181 (24.9%) patients had albumin deficiency classified and it was severe in 24 (5.3%) patients, moderate in 18(4.1%) patients, and mild in 3 (0.7%) patients.

Further nutritional deficiencies were scarcely reported such as Vitamin D in 22 (4.9%) patients, Calcium in 13 (2.9%) patients, Selenium in 10 (2.2%), Vitamin A in 6 (1.3%) patients, Copper in 5 (1.1%) patients, Folate in 4 (0.9%) patients, Thiamine and Zinc in 9 (2%) patients each and Vitamin E and Vitamin B12 in 1 (0.2%) patient each. Deficiency of Vitamin K was not reported at all. In 373 (83.6%) patients, no symptoms were reported. Pedal oedema was the most common symptom reported in 38 (8.5%) patients followed by physical weakness in 35 (7.8%) patients. A further 32 (7.2%) patients presented with diarrhoea, and another 10 (2.2%) patients were reported to have liver failure as presentation. Dysphagia was reported in 2 (0.4%) patients.

British obesity and metabolic surgery society (BOMSS) recommended standard post-operative blood tests were performed in 151 patients (33.8%) (25). Other additional bloods tests like pre-albumin, c-reactive protein (CRP), arterial blood gas (ABG), viral markers were reported in a further 11 (2.4%) patients. Specialist investigations such as bile salt malabsorption test, faecal elastase test and test for bacterial overgrowth were not reported. Investigations reported were: oesophagogastroduodenoscopy (OGD) in 62 (13.9%) patients, upper gastro-intestinal (UGI) contrast studies in 24 (5.4%) patients, ultrasound abdomen in 13 (2.9%) patients, colonoscopy in 11 (2.5%) patients, computed tomography (CT) scan in 10 (2.2%) patients, and liver biopsy and laparoscopy in 2 (0.4%) patients each**.** Most common finding on OGD was presence of bile in the stomach in 18 patients followed by marginal ulcer in 10 patients. Both findings together were found in eight patients. Gastro-jejunal anastomotic stenosis, efferent limb obstruction, and an enlarged pouch was noted on OGD in one patient each.

Intervention for severe malnutrition and outcomes

A total of 250 (56%) patients underwent revision of OAGB due to malnutrition. The most common surgical intervention was reversal of OAGB to normal anatomy in 126 (28.2%) patients. This was followed by revision of OAGB to SG in 46 (10.3%) patients and OAGB to RYGB configuration in 41 (9.2%) patients. Seventeen (3.8%) patients underwent shortening of the BPL. Among these 9 (2%) patients had RYGB and limb length shortening at revisional surgery concurrently (26). The type of revision was not mentioned in 20 (4.5%) patients. Some

88 (19.7%) patients were managed with artificial nutrition or nutritional supplements of whom 30 (6.7%) received parenteral feeding and 13 (2.9%) received enteral tube feeding. A few patients required intravenous supplements of specific nutrient most common of which was Iron 56 (12.5%). Following intervention, reversal of malnutrition was noticed in 151 (33.8%) patients, 10 (2.2%) did not respond and the outcome was not reported in 285 (63.9%) patients.

Overall, eight (0.02%) deaths were reported. Two patients died due to liver failure (27)(28). One patient was reported to have poor compliance with post-operative follow-up and engagement with the team. The other patient had a reversal gastro-gastrostomy and died within two weeks post-operatively. The common channel was found to be 108 cms on autopsy (28). Three of the reported deaths are from one study (21). One patient was planned for reversal of OAGB but succumbed to sudden myocardial infarction whilst undergoing preoperative work-up. Another patient had severe upper limb soft tissue infection two weeks after receiving artificial nutrition. Cause for third mortality in this series was hepatic encephalopathy and liver failure two weeks after revisional surgery. The liver was reported cirrhotic during revision in this patient. The sixth reported mortality was from a retrospective study and the mortality was after 12 months from the initial surgery(15). This patient developed behavioural changes which led to protein malnutrition and liver failure. Further two deaths are from a large multicentre retrospective study and no additional details were given in the article (29).

Of the 250 (56%) patients who underwent surgical intervention for malnutrition following OAGB, complication such as post-operative leak was reported in five (2%) patients, post-

operative bleeding and gastro-jejunal stenosis in three (1.2%) patients each, and one (0.4%) patient was reported to have internal hernia with bowel obstruction.

Discussion

Malnutrition is a concern after any MBS procedure and OAGB is not an exception. With this systematic review, we aimed to examine the incidence and management of severe malnutrition after OAGB. Fifty studies met the inclusion criteria including 49,991 patients who underwent OAGB of which 446 (0.9%) patients required in-hospital treatment for severe malnutrition. Unfortunately, there were large gaps and variances in the reported data that made it difficult to draw firm conclusions. Basic demographics, BMI, medical co-morbidities, and operative details were scarcely reported. Pre-operative nutritional status was only reported in 59 (13.2%) patients in this review. Of note, as per clinical guidelines cosponsored by the American association of clinical endocrinologists, the obesity society and American society of metabolic and bariatric surgery, assessment of preoperative nutritional status is imperative in patients undergoing MBS, and a thorough checklist is recommended (30). The BPL length was not mentioned in almost two thirds of patients who received treatment for severe malnutrition. We found five patients who developed severe malnutrition with BPL length of 150 cms and the rest 151 patients had a BPL length of more than 150 cms. Similarly, presenting features as well as details of investigations undertaken were not reported in majority of the patients. Over half of the patients with severe malnutrition underwent revisional surgery and reversal of OAGB to normal anatomy was the most common choice. Other procedures included revision of OAGB to SG, or RYGB as well as shortening of BPL. The outcomes following such interventions were not reported in almost two-

thirds of the patients. A total of eight patients died because of severe malnutrition of which four were due to liver failure.

OAGB is now considered a mainstream bariatric procedure with similar if not better outcomes compared to RYGB and SG (11). Standardising the technique of OAGB has been a topic of much debate. When OAGB was first introduced the standard BPL length was 200 cms (31)(32). This length was increased when more weight loss was desired (32), and such modifications led to many variations in practice internationally. Nutrient malabsorption leading to severe malnutrition has been a concern following OAGB and the BPL length can be a crucial contributory factor. Due to isolated cases of severe malnutrition with BPL length of 200cms or more, a shorter BPL measuring 150cms was proposed (33). It has also been suggested to measure the entire length of small bowel to avoid leaving a very short efferent limb to further reduce risk of severe malnutrition (34) as well as keeping the BPL length to 100 and 120 cms (12). Unfortunately, BPL length was not mentioned in most of the patients in our review and when reported the BPL length varied from 150 to 350 cms. Majority of the patients who developed severe malnutrition had BPL length greater than 200 cms, however there were five patients with severe malnutrition with a BPL length of 150 cms. Of these five patients, one had revision to normal anatomy but died within the two weeks due to liver failure (21). This patient had presented originally with PEM due to severe nausea, vomiting, and reflux. Another patient had revision to RYGB with an additional BPL length shortening procedure (26). Further three patients who had malnutrition with BPL length of 150 cms are from one study and the details of their management were not reported (35). In the few patients, where efferent limb was reported huge variations were found

from 80 to 520 cms (20)(21). Despite the large gaps in the reported data, it appears pragmatic to keep the BPL length close to 150 cms especially as good outcomes in terms of weight loss and comorbidity resolution have been reported at this length even in the patients with super obesity (15)(36).

Once a patient with OAGB or any MBS presents with malnutrition, a thorough assessment by a multidisciplinary team is crucial. However, we found that such assessments were scarcely reported in the included studies. The underlying reasons remain unclear as to whether such assessments were undertaken but not reported or not undertaken at all. Based on the findings of the review, current limited evidence, and the authors' experience, we propose an algorithm (Figure 2) that may be followed to ensure a thorough clinical assessment, and aid treatment planning (37)(38). More recently, sarcopenic obesity (SO) is increasingly mentioned in the assessment and follow up of patients (39). This is the combination of reduced skeletal muscle function in the presence of high body fat percentage and could be an effective tool for assessing and staging the patients undergoing MBS. We found that 99 (22.2%) patients could be managed with intense dietitian consultations along with replacement of a specific micronutrient with or without a short period of artificial nutrition. However, 250 (56%) patients with severe malnutrition went on to have surgical revision of OAGB. The most common choice was revision to normal anatomy which was performed by division of the gastrojejunostomy and formation of gastro-gastrostomy between the gastric pouch and remnant stomach. In patients who develop malnutrition secondary to an ulcer or stricture at the gastro-jejunal anastomosis (GJA) OAGB may be revised to a RYGB configuration with resection of the GJA as the primary pathology is

thought to be biliary reflux. Shortening of the BPL, which was seen in about 4% of the patients with severe malnutrition, also seems a reasonable option to consider especially in patients who have a BPL of more than 150 cms and was a recommended option in a large multi-centre study from the UK. However, just over 10% of patients had their OAGB reversed to SG. Although there was no mention of why SG was preferred, revision to SG was reported mainly by two authors (40)(41). Both the authors described the technique as dividing the GJA and anastomosing the vertical pouch to the antrum. The greater curvature is then dissected, and the remnant stomach is resected over a 36 Fr orogastric tube in one study and over an endoscope in the other. There is a paucity of publications examining malnutrition after MBS and specifically OAGB. Majority are retrospective series and case reports that are included in our review. A recent narrative review examined revisional surgery after OAGB in general including for malnutrition (42). Although they only looked at surgical intervention, their findings were comparable to our review with 0.84% patients (153 out of 17938) undergoing reoperations for malnutrition-related complications after OAGB (42).

The main limitation is the large gaps in the reported data amongst the studies included in the systematic review, which can undermine the reported results. Secondly, there is wide heterogeneity amongst the types of studies included such as retrospective studies, case series, randomised control trial, case reports, and letter to editor, which makes it difficult to pool the data. Often in the large retrospective studies, finer details were missing. In this review we have only reported on severe malnutrition that required in hospital treatment, and we appreciate many more patients may present with milder versions of malnutrition after OAGB, which hopefully can be managed with input from specialist dietitians and oral supplements. Nonetheless this is

the first systematic review specifically examining severe malnutrition following OAGB. We would also like to highlight the limitation in using serum albumin levels as a marker for nutrition. American society of parenteral and enteral nutrition (ASPEN) position statement recommends use of albumin and prealbumin as markers of inflammation and for assessment of nutritional risk rather than primary nutritional markers (43).

Conclusion

Malnutrition following OAGB is a rare but serious complication as a number of patients may require in-hospital treatment including revisional surgery. The risk of severe malnutrition appears to be higher when the BPL length is greater than 150 cms. However, there were significant gaps in the reported literature. The number of patients who undergo OAGB is bound to increase in near future now that both IFSO and ASMBS recognise it as a mainstream MBS procedure. The bariatric surgeons globally need to standardise the BPL length as well as capacity of the gastric pouch. These should be measured and reported in the OAGB procedure as this will help clinicians manage complications related to malnutrition. Robust prospective data should be collected to report adverse events such as severe malnutrition to improve understanding of incidence and clinical management thereof. We recommend that bariatric surgeons report similar complications with as many details as possible, as it can be a learning experience for surgeons globally. Surgeons should also be encouraged to complete the respective national and/or international bariatric surgery registry to allow data collection and analysis on specific clinical outcomes to inform future guidelines.

Ethical approval

For this type of review, institutional ethical approval was not required.

Statement of consent and conflict of interest:

The authors have no conflicts of interest or financial interests to declare. The manuscript has been reviewed by all the co-authors. As this article is a systematic review, the statement of consent and the statement for human and animal rights are not applicable.

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