# Characteristics of Bariatric Patients on Home Parenteral Nutrition

Theresa Bergholz

A thesis

submitted in partial fulfillment of the

requirements for the degree of

Master of Science

University of Washington

2017

Committee:

Lingtak-Neander Chan

Shirley Paski

Program Authorized to Offer Degree:

Nutritional Sciences Program, School of Public Health

University of Washington

## Abstract


Characteristics of Bariatric Patients on Home Parenteral Nutrition

Theresa Bergholz

Chair of the Supervisory Committee:

Lingtak-Neander Chan, PharmD, BCNSP

Professor and Vice Chair, Department of Pharmacy

Interdisciplinary Faculty, Graduate Program in Nutritional Sciences

**Background:** Corresponding to rising obesity rates, bariatric surgery is becoming a common intervention for obesity. Due to surgical or nutritional complications, some bariatric surgery patients may end up requiring nutritional support in the form of parental nutrition (PN). Historically, PN has been utilized by patients with intestinal failure to increase energy intake for weight gain or weight maintenance, and home parenteral nutrition (HPN) is indicated for patients requiring long-term PN.

Few studies have explored the characterization of bariatric patients receiving HPN. There is no established clinical guidelines or consensus on how to provide optimal nutrition support to this patient population. The primary aim of this study is to characterize the population of bariatric surgery patients on HPN.  The secondary aim is to analyze nutrient provision in the bariatric patient on HPN and to determine if nutrient provision differs across BMI categories.

**Methods:**  Data were accessed from the American Society for Parenteral and Enteral Nutrition's (ASPEN) prospective HPN patient care data registry, the Sustain™ Registry.  The Sustain™ Registry enrolled 1251 subjects from 29 academic medical center, hospital, and home care service sites between 2011 and 2014.  Demographic and anthropometric data, indications for HPN, HPN prescriptions, medications, and other variables relating to the delivery of HPN were collected.  This study will focus on the subset of patients who have undergone bariatric surgery.  Descriptive statistics calculated for continuous variables included means and standard deviations, and for categorical variables, frequency and percentages.  Total daily energy intake and macronutrient intake were compared across BMI classes with linear regression.

**Results:**  Of the 1251 patients enrolled in A.S.P.E.N.'s Sustain™ Registry of patients receiving HPN, 82 (6.6%) had a history of bariatric surgery at baseline and were included in this study.  Most of the patients were female (85%) and Caucasian (67%), and the average age at time of enrollment was 49 ± 10 years.  Nearly half of the patients (45%) were obese.  The most common indication for HPN was gastrointestinal fistula (20%) followed by intractable vomiting (16%), non-short bowel diarrhea (15%), and short bowel syndrome (12%).

Mean daily total energy intake ranged from 20.6 to 32.8 kcal/kg with protein comprising 1.56 to 1.96 g/kg.  There was a significant negative association between daily total energy provision and increasing BMI category with a mean decrease in total energy provision of 1.96 kcal/kg/day with each increasing BMI category.  There was a significant negative association between daily dextrose provision with a mean decrease of 0.52g/kg with increasing BMI category while no association was demonstrated between protein or fat provision and BMI category.

**Conclusion:** Nutrient provision for bariatric patients on HPN varies across BMI categories with a negative association between energy provision and increasing BMI category. Variations in dextrose provision comprise the difference in energy provision. Additional studies are needed to examine the effect of nutrition interventions in this population.

# TABLE OF CONTENTS

Acknowledgements .......... 1

Introduction .......... 2

Methods .......... 5

1. Source of data and procedures .......... 5
2. Statistical analysis .......... 6

Results .......... 6

Discussion .......... 9

Tables and figures .......... 15

Bibliography .......... 33

## ACKNOWLEDGEMENTS

I would like to acknowledge my committee members, Dr. Lingtak Chan and Dr. Shirley Paski, for their guidance on this project. I would also like to thank Katty Tseng, M.S. for her insightful comments on this thesis. Finally, I would like to thank Dr. Peter Cavanagh and the C.O.R.E. lab for their encouragement and support throughout my years of study.

## INTRODUCTION

Bariatric surgery continues to provide the most effective method for long term weight loss and weight maintenance in obese patients.[1,2] A recent clinical trial demonstrated Roux-en-Y gastric bypass (RYGB) more effective than intensive lifestyle and medical intervention in ameliorating type 2 diabetes in mildly to moderately obese patients.[3] Bariatric surgery is now being recommended as a treatment consideration for type 2 diabetes (T2D) in patients with class III obesity (body mass index (BMI) $\geq$40 kg/m$^2$) and in patients with class II obesity (BMI 35.0–39.9 kg/m$^2$) who have not achieved adequate glycemic control through diet and/or pharmacotherapeutic intervention, as well as considered as a T2D treatment in patients with class I obesity (BMI 30.0–34.9 kg/m$^2$).[4] These recommendations, coupled with the American Medical Association's 2013 reclassification of obesity from a condition to a disease, will continue to increase the number of bariatric surgeries performed, currently over 200,000 annually in the U.S. [5,6]

Bariatric surgical procedures are classified as restrictive, malabsorptive, or a combination of the two. The RYGB, the most commonly performed bariatric surgery, is a primarily restrictive procedure with a mild malabsorptive component. The stomach is stapled to form a small gastric pouch which limits intake, and malabsorption is achieved by dividing the small intestine and connecting the jejunum to the new gastric pouch to form the Roux limb, which allows the passage of food in bypassing part of the upper small intestine. The degree of malabsorption is dependent on the length of the Roux limb. The pancreaticobiliary limb is anastomosed distal to the gastrojejunal anastomosis to allow the entrance of bile salts and digestive enzymes distally into the common channel. Purely restrictive procedures, laparoscopic adjustable gastric band

(LAGB) and vertical sleeve gastrectomy (VSG), function through the creation of a small gastric pouch by either placing a silicone ring around a portion of the stomach or stapling part of the stomach along the larger curvature to create a tube-like structure, respectively. The biliopancreatic diversion (BPD) is the most malabsorptive procedure with the greatest length of intestines bypassed to minimize nutrient digestion and absorption.[7] Fewer nutritional complications are associated with the purely restrictive procedures but still may occur due to decreased intake in general or intolerance of certain foods after the procedure.[8] Patients undergoing malabsorptive procedures are at significantly higher risk for malnutrition and micronutrient deficiencies. Primary malabsorption from the surgical alteration of the gut may be augmented by a secondary malabsorption due to decreased gastrointestinal transit time. Malnutrition in the setting of bariatric surgery may result from insufficient nutrient intake, digestion, and/or absorption. Protein malnutrition incidence in BPD has been estimated as high as 21%.[8] Additionally, while there are limited data on post-bariatric surgical patient adherence to lifestyle and diet recommendations, one study found that only 40% achieved the recommended protein intake of greater than 60 grams per day in the first year following bariatric surgery.[9] Due to malabsorption created by bariatric surgery, micronutrient deficiencies are also common in this group, especially deficiencies in iron, calcium, and vitamin D.[7] Nutritional complications may arise in the early post-operative period or years later. Commonly reported surgical complications of bariatric procedures include anastomotic leaks, fistulas, and bowel obstructions.[10,11] Some bariatric procedures have also been associated with malnutrition due to bowel discontinuity or loss of absorptive area.

Both post-operative malnutrition and surgical complications may lead to a requirement for specialized nutritional support. Guidelines for the nutritional support of the bariatric patient recommend enteral nutrition (EN) as preferred therapy, but if EN is not feasible with severe loss of gastrointestinal function, patients may require parenteral nutrition (PN).[12] Home parenteral nutrition (HPN) is an option for medically stable patients who are expected to require long term PN support. Little is known about the provision of HPN in the setting of status post bariatric surgery.

A consideration unique to the bariatric patient is the need to balance the prevention of malnutrition with the avoidance of overfeeding and its associated risks. Historically, PN has been used to prevent or treat malnutrition. There are limited data on estimating the energy requirements of patients on HPN, especially the obese patient on HPN. While it is well established that indirect calorimetry is the gold standard for estimating energy needs,[13] its expense and limited availability may preclude more common use. Outside of the hospital setting, energy needs are more often assessed using predictive equations for estimating resting energy expenditure (REE). Studies in gastric bypass patients demonstrate varying correlation with predictive equations and actual resting energy expenditure. Several studies have shown the Harris-Benedict equation is a reliable predictor of REE in patients who have undergone gastric bypass. In a study of women post RYGB surgery, Ramirez-Marrero, et.al determined that both Harris-Benedict and Mifflin-St. Jeor equations adequately predict REE in this population.[14] However, predictive equations overall have demonstrated low accuracy in determining energy needs of obese patients.[15] More importantly, given that these data were obtained in the immediate postoperative setting, it is not known whether results of these studies have informed practice in determining energy needs of bariatric patients on HPN, let alone obese bariatric patients on HPN. In general, there are few studies examining incidence and outcomes in patients on HPN[16] with less known about the bariatric patient requiring HPN.

The primary aim of this study is to characterize the population of bariatric surgery patients on HPN using a national HPN database. The secondary aim is to analyze nutrient provision in the bariatric patient on HPN and to determine if nutrient provision differs across BMI categories.

## METHODS

### 1. Source of data and procedures

De-identified data were obtained from the A.S.P.E.N. Sustain™ Registry which captured prospective data from patients on HPN enrolled at 29 U.S. hospital and home infusion sites between 2011 and 2014. Data variables included demographic information, underlying diagnosis, indication for HPN, nutrient provision, medications, laboratory values, concurrent oral and enteral nutrition, weight change or maintenance goals, and catheter type.[17]

Patients with a history of bariatric surgery, as categorized in the database, were included in this study. Daily provision of dextrose, protein, and fat was analyzed as grams per kilogram. The Sustain data captured actual weight and height for subjects. Energy requirements in obese patients are commonly estimated based on adjusted body weight to account for the less metabolically active adiposity.[18] In determining nutrient provision by weight in obese subjects, actual body weight was transformed to adjusted body weight (ABW) using ideal body weight (IBW) approximated by the Devine formula.[19] Adjusted body weight was calculated as 0.25 x (Actual body weight - IBW) + IBW. One subject had no value listed for current weight so usual weight was used for calculating ABW. A height listed for one subject was below the range of height to use the Devine formula, so the height was rounded up to the lowest acceptable value. For purposes of this analysis, obesity was defined as a BMI greater than or equal to 30 $kg/m^2$.

Energy and macronutrient intake, as well as weight loss goals, and type of intravenous catheter used were compared by divisions of BMI category: underweight (BMI <18.5 $kg/m^2$), normal weight (BMI 18.5-24.9 $kg/m^2$), overweight (BMI 25.0-29.9 $kg/m^2$), obese class I (BMI 30- 34.9 $kg/m^2$), obese class II (BMI 35.0–39.9 $kg/m^2$), and obese class III (BMI ≥40 $kg/m^2$). Raw data expressed intake as g/day and were transformed to g/kg/day for comparisons. For analysis of energy and macronutrient intake in the three obese categories, ABW was used.

## 2. STATISTICAL ANALYSIS

Descriptive statistics calculated for continuous variables included means and standard deviations, and for categorical variables, frequency and percentages. These parameters were determined using Microsoft Excel 2016 (Microsoft Corporation, Redmond, WA). Total daily energy intake and macronutrient intake were compared across BMI categories with linear regression using STATA 14 (StataCorp LLC, College Station, TX), and data distribution was displayed by box and whisker diagram using GraphPad Prism 7.03(GraphPad Software, Inc. La Jolla, CA). A p value of < .05 was considered statistically significant.

## RESULTS

Of the 1251 patients enrolled in A.S.P.E.N.'s Sustain™ Registry of patients receiving HPN, 82 (6.6%) had a history of bariatric surgery at baseline and were included in this study. Most the patients were female (85%) and Caucasian (67%). The average age at time of enrollment was 49 ± 10 years (Table 1, 2).

The most common indication for HPN was gastrointestinal fistula (20%) followed by intractable vomiting (16%), non-short bowel diarrhea (15%), and short bowel syndrome (12%). It is worth noting that short bowel syndrome was also noted as an underlying diagnosis in 12.2% of the patients with bariatric surgery (Table 3). Five patients had a stoma.

The majority of patients (77%) utilized at least one GI medication (Table 4). No patients received concurrent enteral nutrition through a feeding tube. Concurrent oral nutrition was described as ad libitum diet (30%), restricted oral therapeutic diet (11%), and diet of liquid for oral rehydration only (11%). Forty-eight percent of the patients received no oral nutritional intake (Table 5).

According to their BMI classification, less than half the patients who previously had bariatric surgery were obese (45%) at the time of HPN initiation, whereas 9% were underweight, 20% were normal weight, and 27% were overweight. All underweight patients indicated a goal of weight gain, 55% of normal to overweight patients indicated a goal of weight maintenance, and 89 % of obese patients indicated a goal of weight loss (Table 6).

Baseline laboratory parameters were all within normal range except for albumin which was below the normal reference range (Table 7). The majority of underweight subjects utilized a tunneled catheter in contrast to the more common utilization of peripherally inserted central catheters (PICC) in the other BMI categories (Table 8). The primary provider of health insurance was private (65%) followed by Medicare (28%) (Table 9).

Across all BMI categories, mean daily total energy intake ranged from 20.6 to 32.8 kcal/kg (Table 10) with protein comprising 1.56 to 1.96 g/kg (Table 11). A simple linear regression analysis was performed to determine the relationship between daily energy provision in kcal/kg and weight category: underweight (BMI <18.5 kg/m$^2$), normal weight (BMI 18.5-24.9 kg/m$^2$), overweight (BMI 25.0-29.9 kg/m$^2$), obese class I (BMI 30- 34.9 kg/m$^2$), obese class II (BMI 35.0–39.9 kg/m$^2$), and obese class III (BMI ≥40 kg/m$^2$). Our data demonstrated a negative association between daily total energy provision and increasing BMI category (Fig. 1) with patients with a higher BMI more likely to receive fewer daily calories from HPN with a mean reduction of 1.96 total kcal/kg/day with each increasing BMI category ($r = -0.48$, $p<0.05$). In contrast, no significant association was found between total daily protein provision by HPN and BMI category (Fig. 2), ($r = 0.1$, $p = 0.52$). Similarly, there was no significant association observed between estimated mean daily fat provision and BMI category (Fig. 3), ($r = -0.14$, $p = 0.17$). Weekly fat provision ranged from 3-4 g/kg/week (Table 12) with estimated mean daily fat provision ranging from 0.4-0.6 g/kg/day (Table 13). Our data demonstrated a negative association between daily total daily dextrose provision by HPN and increasing BMI category (Fig. 4) with patients with a higher BMI more likely to receive fewer daily grams of dextrose per kilogram from HPN with a mean reduction of 0.52 g/kg/day with each increasing BMI category ($r = -0.5$, $p<0.05$).

Mean daily dextrose ranged from 3-6 g/kg/day, or 2.1 to 4.2 mg/kg/min (Table 14). Mean daily fluid provision ranged from 29-46 ml/kg/day (Table 15) with an apparent positive association between fluid provision with patients with a higher BMI more likely to receive a mean increase of 3.17 ml/kg daily fluid provision (ml/kg) with increasing BMI category ($r = 0.45$, $p<0.5$).

## DISCUSSION

The percentage of patients on HPN with an underlying diagnosis of bariatric surgery, 6.6%, was similar to findings of another study of an HPN database in which 6.3% of patients shared this diagnosis.[11] Also in line with other studies and reflective of the majority of patients undergoing bariatric surgery in the U.S,[20] the group of bariatric patients on HPN were comprised mainly of Caucasian women. In the literature, the most frequent surgical complication of bariatric surgery, anastomotic leak, has been reported as the most common indication for PN along with fistula. Short bowel syndrome, chronic nausea/vomiting, and diarrhea are also commonly reported indications.[,21,22,23,24] While the Sustain[TM] dataset did not include a variable specifically for anastomotic leak, reported indications for HPN in this study reflected those seen in previous studies with fistula as most common followed by vomiting, diarrhea, and short bowel syndrome.

Baseline laboratory parameters were all within normal range with the exception of albumin which, as a negative acute phase protein, is expected be decreased during acute and chronic inflammation and may also be decreased in the setting of severe malnutrition and volume overload.

The majority of obese patients in our study (89 %) indicated a goal of weight loss. This goal seems appropriate for an obese patient in the post-bariatric surgery setting, with the goal of maintaining lean body mass while reducing fat mass. Currently there are no guidelines on how to achieve this. A database study of 23 obese bariatric patients on HPN who received hypocaloric, high protein feeds for a mean duration of 1.5 months demonstrated a 7.1% decrease in BMI while maintaining nutrition status.[21]

Choice of central catheter was different across weight categories of our study. The European Society for Clinical Nutrition and Metabolism (E.S.P.E.N.) guidelines for general parenteral nutrition support recommend tunneled catheters over PICC for HPN use,[25] but with the exception of the underweight subjects, PICC was more commonly utilized. A recent study of the HPN population has shown a similar trend in PICC for catheter choice,[26] and PICCs have been shown to be safe for long term PN use.[27] The choice for PICC over tunneled line was most likely determined by whether or not the PN was anticipated to be very long term as might be the case with severe malabsorption or persistent dumping versus a potentially shorter time period for instances with potential for resolution such as fistula closure. Underweight patients are more likely to require long term PN post-bariatric surgery given the degree of weight loss that resulted in becoming underweight.

Subjects in our study received an average of 20.6 to 32.8 kcal/kg daily which is in line with E.S.P.E.N. guidelines advising a total caloric intake of 20–35 kcal/kg per day for HPN patients.[12]

More specifically, in this study we observed a trend in declining energy provision with increasing BMI. With 45% of the subjects obese and receiving 20-22 kcal/kg per day, this may reflect a trend of providers moving towards adapting the A.S.P.E.N. clinical guidelines for nutrition support of critically ill or hospitalized obese patients recommending hypocaloric (<14 kcal/kg) feeding for this patient population [28] though the post bariatric patient on HPN examined in this study is not critically ill. Additionally, this cohort may be requiring nutritional support well past the time of surgery. In a randomized trial of hospitalized patients requiring PN which specifically did not limit inclusion to the obese or critically ill, permissive underfeeding, defined as providing 60% of estimated energy requirement, appeared to reduce septic and feeding complications including line sepsis.[29] While the HPN population is incomparable to the hospitalized or critical care bariatric patient needing PN, reducing total energy requirements may have been done for a variety of reasons including reducing hyperglycemia, because of concurrent oral or enteral intake, or with the goal of steady weight loss in the more obese patient.

The A.S.P.E.N. guidelines also recommend a higher protein provision (1.2 g/kg actual body weight or 2-2.5 g/kg ideal body weight).[28] Interestingly, a survey study of A.S.P.E.N. members asked about care of their bariatric patients demonstrated a lack of consensus among the specialists on which weight to use to estimate calorie and protein needs. However, ABW was used more often than IBW or actual body weight in estimating calorie and protein goals.[23] Our study, using ABW in determining protein needs, does not demonstrate an association between protein provision and body weight with an average daily provision of 1.56 to 1.96 g/kg. The bariatric patient's increased need for protein is two-fold in that they are at increased risk of PEM, and increased protein provision is indicated for wound healing.[8] Determining adequacy of protein provision in the HPN patient remains challenging as traditional markers of visceral protein status such as albumin and prealbumin are negative acute phase proteins and will be depressed in the setting of inflammation, and performing nitrogen balance studies in an outpatient setting is not realistic.[21] Furthermore, absorption of dietary protein is variable in the post-bariatric state (especially in the setting of a high output fistula), and intake may be further limited due to gastrointestinal symptoms. Careful clinical monitoring and adjustment of protein provision is essential for long term HPN provision.

There was no observed difference among BMI categories in daily fat provision. Despite hyperglycemia being the most common complication of PN[30] the difference among BMI categories in total caloric provision was dextrose. This suggests, at least for the 48% of patients who were NPO, the providers considered the complications associated with protein administration and lipid injectable emulsion (ILE) administration outweighed those of dextrose administration. ILE provides a significant source of energy reducing the requirement for dextrose and incidence of complications associated with its administration in excess, including hyperglycemia and hepatic steatosis. Moreover, ILE is necessary to prevent essential fatty acid deficiency and should comprise up to 15-30% of total calories for a patient receiving PN.[31] Despite the requirement for ILE, long term administration is associated with significant complications such as an increased risk for catheter-related bloodstream infections, lipid profile derangements, and parenteral nutrition-associated liver disease (PNALD) [31.] At the time of the Sustain[TM] data collection, soybean oil-based lipid emulsion was the only ILE approved by the Food and Drug Administration for use in the United States. As other lipid emulsions become available that allow better lipid tolerance and lower risk for long-term complication, we may see changes in the provision of lipids in PN in the future. More studies are needed to determine how this will impact on HPN provision of lipids the bariatric population.

## Strengths and Limitations

While this study is a retrospective examination, the data was collected prospectively and comprised a robust sample. As the purpose of the primary data collection was to collect information on patients who require HPN in the United States[16] and not a study of bariatric patients on HPN in particular, information that would elucidate the relationship between bariatric surgery and the need for HPN was not collected, such as date of surgery in relation to initiation of HPN and type of bariatric surgery.[10,11] As a result, we were unable to determine if PN was primarily used to manage temporary peri-operative complications or long term complications like adhesive disease or many years of severe malabsorption culminating in malnutrition. For instance, one study differentiated between early and late complications of bariatric surgery leading to requirement for nutritional support.[10] Description of the bariatric population on HPN in our study would have been more complete if these variables had been collected. A more detailed examination of the timing of complications leading to HPN would serve to inform post-operative nutritional management of the bariatric patient. Are complications arising immediately post-operatively or years later, and is there a window for prevention for at least the non-surgical complications? Additionally, our assumption that ABW was used in determining total energy and macronutrient requirements for obese patients cannot be verified. Also, oral intake data was categorical, and how much oral intake contributed to total energy is unknown. Oral intake is highly variable in the post-bariatric surgery patient, and even when eating, the degree of absorption and malabsorption is dependent on a number of factors including: gastrointestinal motility, mucosal integrity, length of common channel, food preparation techniques, and timing by which the food is consumed. Moreover, reported nutrient provision from PN may not reflect actual intake as there may be some variability in adherence to the HPN prescription. Finally, while A.S.P.E.N.'s Sustain™ registry did capture follow-up visit data, none was available for subjects in this cohort. Collection of long term body weight, body composition, and nutrition provision would help better define this cohort and whether or not the provision of HPN was appropriate to meet the nutritional goals.

## Future Direction

There are limited studies to inform nutrition therapy in the malnourished, non-critically ill, obese patient. Additionally, this study described subjects at baseline. If data from subsequent visits were available, success in achieving weight maintenance or weight change goals could be examined. Further studies are needed to determine what nutritional intervention is best to achieve a goal of weight loss in an obese patient on PN. This registry captured data on patients receiving HPN. A future registry of bariatric patients on HPN that follows patients for a longer time period, beyond completion of HPN administration, would allow for more detailed evaluation of the impact of differing HPN formulations on clinical outcomes in this complex, diverse patient population.

## Conclusion

Given the rising rate of obesity coupled with the recent recommendations of treating T2D with bariatric surgery, the number of bariatric procedures performed annually will likely increase significantly. Bariatric patients comprised a substantial number of patients in the SUSTAIN study, and nearly half of them were NPO. Patients considering bariatric surgery should be advised that potential complications may lead to the requirement for parenteral nutrition.

## TABLES AND FIGURES

**Table 1. Baseline Demographics (n = 82)**

| Characteristic | | N | Percentage |
|---|---|---|---|
| Sex | Men | 12 | 14.6 |
| | Women | 70 | 85.4 |
| Race | White | 55 | 67.1 |
| | African American | 18 | 22.0 |
| | Other | 9 | 11.0 |
| **Characteristic** | | **Mean ± SD** | **Median, [min, max]** |
| | Age (years) | 48.8 ± 10.5 | 48.5 [26.2, 67.0] |
| | BMI (kg/m2) | 30.1 ± 9.1 | 29.2 [15.1, 57.1] |
| | Height (cm) | 164.9 ± 8.7 | 163.0 [145.0, 191.0] |

**Table 2. Baseline Weight Distribution (n = 82)**

| Weight by Category | N | Weight Assessment | Mean ± SD (kg) | Median [min,max] |
|---|---|---|---|---|
| Underweight (BMI <18.5) | 7 | Actual Weight | 45.0 ± 4.2 | 46.0 [38.6, 39.9] |
| Normal Weight (BMI 18.5-24.99) | 16 | Actual Weight | 60.9 ± 8.8 | 58.5 [50.0, 85.0] |
| Overweight (BMI 25.00-29.99) | 22 | Actual Weight | 74.8 ± 6.9 | 75.6 [62.7, 85.0] |
| Obese Class I (BMI 30.0- 34.99) | 15 | Actual Weight<br>ABW | 87.1 ± 9.4<br>64.3 ± 8.3 | 85.5 [70.0, 107.0]<br>63.8 [51.7, 81.9] |
| Obese Class II (BMI 35.0- 39.99) | 10 | Actual Weight<br>ABW | 101.8 ± 8.3<br>67.4 ± 6.1 | 103.5 [90.0, 115.0]<br>66.8 [60.2, 77.9] |
| Obese Class III (BMI ≥ 40.0) | 12 | Actual Weight<br>ABW | 132.6 ± 28.7<br>78.0 ± 14.6 | 128.5 [100.0, 193.0]<br>76.7 [61.3, 108.7] |

**ABW = adjusted body weight (0.25 x (Actual body weight - IBW) + IBW)**

**Table 3. Other Diagnoses and Indications for HPN (n=82)**

| Other Diagnosis | N | % |
|---|---|---|
| Short Bowel Syndrome | 10 | 12.2 |
| Mesenteric Ischemia | 3 | 3.7 |
| Gastromotility Disorder | 2 | 2.4 |
| GI Cancer | 1 | 1.2 |
| Gynecological Tumor | 1 | 1.2 |
| Hyperemesis Gravidarum | 1 | 1.2 |
| **Indication for HPN** | | |
| Gastrointestinal Fistula | 16 | 19.5 |
| Intractable Vomiting | 13 | 15.9 |
| Non-short Bowel Diarrhea | 12 | 14.6 |
| Short Bowel Syndrome | 10 | 12.2 |
| Gastrointestinal Obstruction | 4 | 4.9 |
| Bowel Dysmotility | 4 | 4.9 |
| Chemotherapy Associated GI Dysfunction | 1 | 1.2 |

| | | |
|---|---|---|
| Mesenteric Ischemia | 1 | 1.2 |
| Other | 28 | 34.1 |

More than one category could be selected per patient

**Table 4. Medications (n=82)**

| | | |
|---|---|---|
| GI Meds* | **63** | **76.8** |
| Anti-ulcer/acid suppression | 38 | 46.3 |
| Antiemetic | 23 | 28.0 |
| Prokinetic | 21 | 25.6 |
| Antidiarrheal | 11 | 13.4 |
| Cathartic | 9 | 11.0 |
| Other GI Meds (Digestant, Emetic, Anti-flatulent) | 7 | 8.5 |
| Vitamins | 44 | 53.7 |
| Pain | 39 | 47.6 |
| Cardiovascular | 22 | 26.8 |
| Hormones | 18 | 22.0 |
| Antibiotic | 13 | 15.9 |
| Other | 23 | 28.0 |

*Multiple options available

**Table 5. Diet Type (n = 82)**

| Diet Type | n | % |
|---|---|---|
| NPO | 39 | 47.6 |
| Food intake ad libitum | 24 | 29.3 |
| Restricted therapeutic diet | 9 | 11.0 |
| Liquid for oral rehydration | 9 | 11.0 |
| Unknown | 1 | 1.2 |

**Table 6. Weight loss goals at baseline among HPN patients (n = 82)**

| BMI Category | | n | % |
|---|---|---|---|
| BMI < 18.5 (n = 7) | | | |
| | Weight Loss | 0 | 0.0 |
| | Weight Maintenance | 0 | 0.0 |
| | Weight Gain | 7 | 100.0 |
| | Not Specified | 0 | 0.0 |
| BMI 18.5 – 29.9 (n = 38) | | | |
| | Weight Loss | 8 | 21.1 |
| | Weight Maintenance | 21 | 55.3 |
| | Weight Gain | 6 | 15.8 |
| | Not Specified | 3 | 7.9 |
| BMI ≥ 30.0 (n = 37) | | | |
| | Weight Loss | 33 | 89.2 |
| | Weight Maintenance | 2 | 5.4 |

| | | |
|---|---|---|
| Weight Gain | 0 | 0.0 |
| Not Specified | 2 | 5.4 |

Due to rounding, percentages may not sum to 100.

**Table 7. Baseline Laboratory Values Among Adult Bariatric HPN Patients**

| Laboratory Test | N | Mean ± SD | Median [min,max] |
|---|---|---|---|
| Albumin (g/dL) | 79 | 3.0 ± 0.6 | 2.9 [1.6, 4.7] |
| ALT (U/L) | 60 | 37.1 ± 42.2 | 24.0 [8.0, 262.0] |
| AST (U/L) | 77 | 35.6 ± 53.4 | 24.0 [8.0, 451.0] |
| Direct Bilirubin (mg/dL) | 35 | 0.2 ± 0.2 | 0.1 [0.0,1.2] |
| BUN (mg/dL) | 78 | 21.6 ± 14.0 | 18.0 [5.0,99.0] |
| Creatinine (mg/dL) | 78 | 0.8 ± 1.2 | 0.6 [0.2, 8.9] |
| Platelet ($10^3$ cells/mL) | 76 | 288.0 ± 150.5 | 269.0 [6.7, 982.0] |
| INR | 35 | 1.1 ± 0.2 | 1.1 [1.0, 1.7] |

**Table 8. Catheter type among HPN patients (n = 82)**

| Catheter Type | | n | % |
|---|---|---|---|
| BMI < 18.5 (n = 7) | | | |
| | PICC | 1 | 14.3 |
| | Tunneled | 6 | 85.7 |
| | Port | 0 | 0.0 |
| BMI 18.5 – 29.9 (n = 38) | | | |
| | PICC | 29 | 76.3 |
| | Tunneled | 9 | 23.7 |
| | Port | 0 | 0.0 |
| BMI ≥ 30.0 (n = 37) | | | |
| | PICC | 29 | 78.4 |
| | Tunneled | 5 | 13.5 |
| | Port | 3 | 8.1 |

**Table 9. Insurance type among HPN patients (n=82)**

| Insurance | n | % |
|---|---|---|
| Private | 53 | 64.6 |
| Medicare | 23 | 28.0 |
| Medicaid | 5 | 6.1 |
| Medicare Supplements | 1 | 1.2 |

**Table 10. Bariatric Patients HPN Prescription: Total Energy kcal/kg (n = 82)**

| | Weight Category | N | Weight Assessment | Mean ± SD | Median [min,max] |
|---|---|---|---|---|---|
| Total Energy kcal/kg/day | Underweight (BMI < 18.5) | 7 | | 32.8± 7.1 | 33.0 [21.5, 44.0] |
| | Normal Weight (BMI 18.5 - 24.9) | 22 | | 27.4 ± 5.2 | 27.6 [15.5, 35.3] |
| | Overweight (BMI 25.0 - 29.9) | 16 | | 20.6 ± 4.1 | 20.0 [14.1, 28.4] |
| | Obese Class I (BMI 30.0 - 34.9) | 15 | Actual Body Weight | 16.3 ± 2.5 | 16.7 [10.4, 19.9] |
| | | | Adjusted Body Weight | 22.2 ± 3.5 | 22.0 [14.0, 28.5] |
| | Obese Class II (BMI 35.0 - 39.9) | 10 | Actual Body Weight | 13.4 ± 2.1 | 13.4 [10.2, 16.6] |
| | | | Adjusted Body Weight | 20.3 ± 3.3 | 21.0 [14.4, 25.4] |
| | Obese Class III (BMI ≥ 40.0) | 12 | Actual Body Weight | 12.7 ± 4.9 | 11.7 [6.1, 23.6] |
| | | | Adjusted Body Weight | 21.4 ± 7.7 | 19.3 [11.1, 39.5] |

**Table 11. Bariatric Patients HPN Prescription: Protein g/kg (n = 82)**

| | BMI Category | N | Weight Assessment | Mean ± SD | Median [min,max] |
|---|---|---|---|---|---|
| Protein (g/kg/day) | Underweight (BMI < 18.5) | 7 | | 1.8± 0.6 | 1.7 [1.2, 2.8] |
| | Normal Weight (BMI 18.5 - 24.9) | 22 | | 1.8 ± 0.3 | 1.8 [0.8, 2.4] |
| | Overweight (BMI 25.0 - 29.9) | 16 | | 1.6 ± 0.3 | 1.5 [0.9, 2.1] |
| | Obese Class I (BMI 30.0 - 34.9) | 15 | Actual Body Weight | 1.3 ± 0.1 | 1.3 [1.1, 1.5] |
| | | | Adjusted Body Weight | 1.8 ± 0.2 | 1.8 [1.5,2.0] |
| | Obese Class II (BMI 35.0 - 39.9) | 10 | Actual Body Weight | 1.1 ± 0.2 | 1.2 [0.8, 1.4] |
| | | | Adjusted Body Weight | 1.7 ± 0.3 | 1.7 [1.2 2.2] |
| | Obese Class III (BMI ≥ 40.0) | 12 | Actual Body Weight | 1.2 ± 0.9 | 1.0 [0.6, 3.9] |
| | | | Adjusted Body Weight | 2.0 ± 1.4 | 1.6 [1.1,6.5] |

**Table 12. Bariatric Patients HPN Prescription: Weekly Fat g/kg (n = 82)**

| | BMI Category | N | Weight Assessment | Mean ± SD | Median [min,max] |
|---|---|---|---|---|---|
| Fat* (g/kg/week) | Underweight (BMI < 18.5) | 7 | | 4.3 ± 2.2 | 4.3 [2.1, 7.4] |
| | Normal Weight (BMI 18.5 - 24.9) | 22 | | 3.5 ± 2.5 | 2.0 [0.4, 7.7] |
| | Overweight (BMI 25.0 - 29.9) | 16 | | 3.0 ± 2.1 | 2.7 [0.0, 6.8] |
| | Obese Class I (BMI 30.0 - 34.9) | 15 | Actual Body Weight | 2.4 ± 1.7 | 1.7 [0.0, 4.7] |
| | | | Adjusted Body Weight | 3.2 ± 2.2 | 2.4 [0.0, 6.4] |
| | Obese Class II (BMI 35.0 - 39.9) | 10 | Actual Body Weight | 2.0 ± 1.6 | 1.3 [0.0, 4.4] |
| | | | Adjusted Body Weight | 3.0 ± 2.4 | 1.9 [0.0, 6.5] |
| | Obese Class III (BMI ≥ 40.0) | 12 | Actual Body Weight | 1.6 ± 1.6 | 1.3 [0.0, 3.9] |
| | | | Adjusted Body Weight | 2.7 ± 2.6 | 2.2 [0.0, 6.4] |

*Not every patient received fat daily

**Table 13. Bariatric Patients HPN Prescription: Average Daily Fat g/kg (n = 82)**

| | BMI Category | N | Weight Assessment | Mean ± SD | Median [min,max] |
|---|---|---|---|---|---|
| Fat (average g/kg/day) | Underweight (BMI < 18.5) | 7 | | 0.6 ± 0.3 | 0.6 [0.3, 1.1] |
| | Normal Weight (BMI 18.5 - 24.9) | 22 | | 0.5 ± 0.4 | 0.3 [0.1, 1.1] |
| | Overweight (BMI 25.0 - 29.9) | 16 | | 0.4 ± 0.3 | 0.4 [0.0, 1.0] |
| | Obese Class I (BMI 30.0 - 34.9) | 15 | Actual Body Weight | 0.3 ± 0.2 | 0.3 [0.0, 0.7] |
| | | | Adjusted Body Weight | 0.5 ± 0.3 | 0.4 [0.0, 0.9] |
| | Obese Class II (BMI 35.0 - 39.9) | 10 | Actual Body Weight | 0.3 ± 0.2 | 0.2 [0.0, 0.6] |
| | | | Adjusted Body Weight | 0.4 ± 0.3 | 0.3 [0.0, 0.9] |
| | Obese Class III (BMI ≥ 40.0) | 12 | Actual Body Weight | 0.2 ± 0.2 | 0.2 [0.0, 0.6] |
| | | | Adjusted Body Weight | 0.4 ± 0.4 | 0.3 [0.0,0.9] |

**Table 14. Bariatric Patients HPN Prescription: Dextrose g/kg (n = 82)**

| | BMI Category | N | Weight Assessment | Mean ± SD | Median [min,max] |
|---|---|---|---|---|---|
| Dextrose (g/kg/day) | Underweight (BMI < 18.5) | 7 | | 5.9 ± 1.9 | 5.8 [3.2, 8.8] |
| | Normal Weight (BMI 18.5 - 24.9) | 22 | | 4.7 ± 1.3 | 4.8 [2.5, 7.0] |
| | Overweight (BMI 25.0 - 29.9) | 16 | | 3.1 ± 0.8 | 3.2 [2.0, 4.0] |
| | Obese Class I (BMI 30.0 - 34.9) | 15 | Actual Body Weight | 2.4 ± 0.6 | 2.3 [1.3, 3.4] |
| | | | Adjusted Body Weight | 3.2 ± 0.9 | 2.4 [1.8,4.5] |
| | Obese Class II (BMI 35.0 - 39.9) | 10 | Actual Body Weight | 1.9 ± 0.7 | 1.6 [1.4, 3.8] |
| | | | Adjusted Body Weight | 2.8 ± 1.1 | 2.5 [1.9, 5.8] |
| | Obese Class III (BMI ≥ 40.0) | 12 | Actual Body Weight | 1.8 ± 0.8 | 1.8 [0.8, 3.5] |
| | | | Adjusted Body Weight | 3.0 ± 1.2 | 3.1 [1.5, 5.7] |

**Table 15. Bariatric Patients HPN Prescription: Fluids mL/kg (n = 82)**

| | BMI Category | N | Weight Assessment | Mean ± SD | Median [min,max] |
|---|---|---|---|---|---|
| Fluids (mL/kg) | Underweight (BMI < 18.5) | 7 | | 36.1 ± 9.4 | 33.9 [25.1, 50.0] |
| | Normal Weight (BMI 18.5 - 24.9) | 22 | | 33.8 ± 10.4 | 32.3 [14.9, 52.9] |
| | Overweight (BMI 25.0 - 29.9) | 16 | | 28.6 ± 8.3 | 28.1 [17.1, 47.9] |
| | Obese Class I (BMI 30.0 - 34.9) | 15 | Actual Body Weight | 27.5 ± 7.1 | 27.1 [19.4, 48.5] |
| | | | Adjusted Body Weight | 42.6 ± 11.8 | 39.6 [27.2, 78.4] |
| | Obese Class II (BMI 35.0 - 39.9) | 10 | Actual Body Weight | 24.6 ± 2.7 | 24.7 [20.9, 28.9] |
| | | | Adjusted Body Weight | 44.9 ± 5.9 | 44.9 [37.2, 55.9] |
| | Obese Class III (BMI ≥ 40.0) | 12 | Actual Body Weight | 21.1 ± 5.4 | 21.6 [11.528.9] |
| | | | Adjusted Body Weight | 46.2 ± 10.5 | 48.4 [27.9, 62.1] |

**FIGURES**

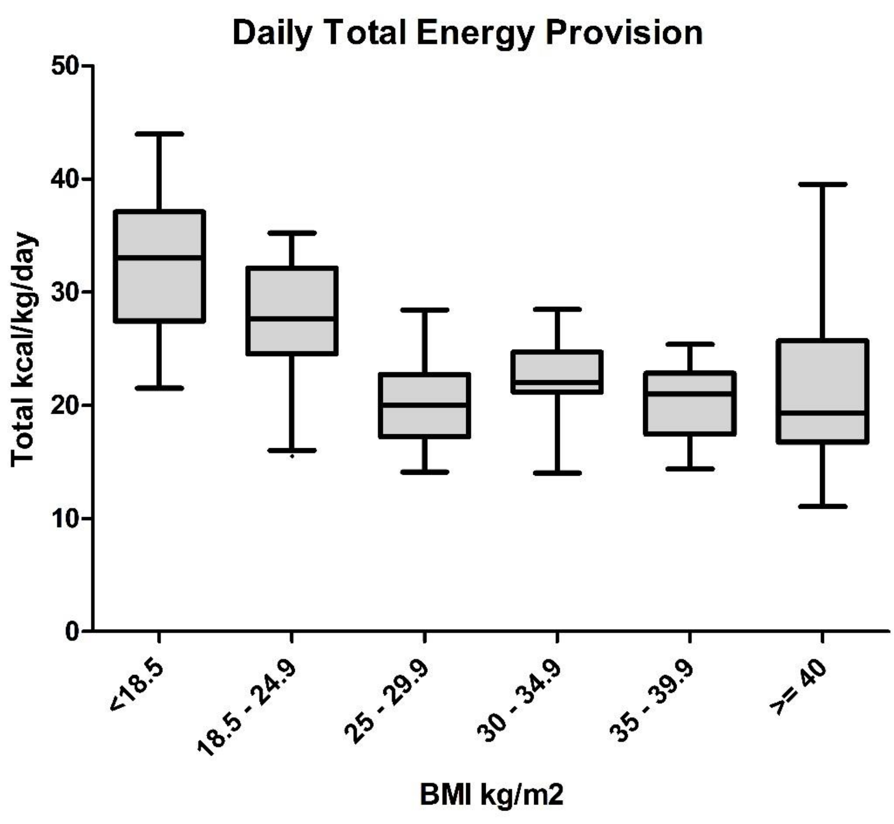


Fig.1. Daily energy provision (kcal/kg) by BMI category.
Box = 25th and 75th percentiles, bars = 5% – 95% confidence interval
For obese subjects, provision estimates based on Adjusted Body Weight were used.

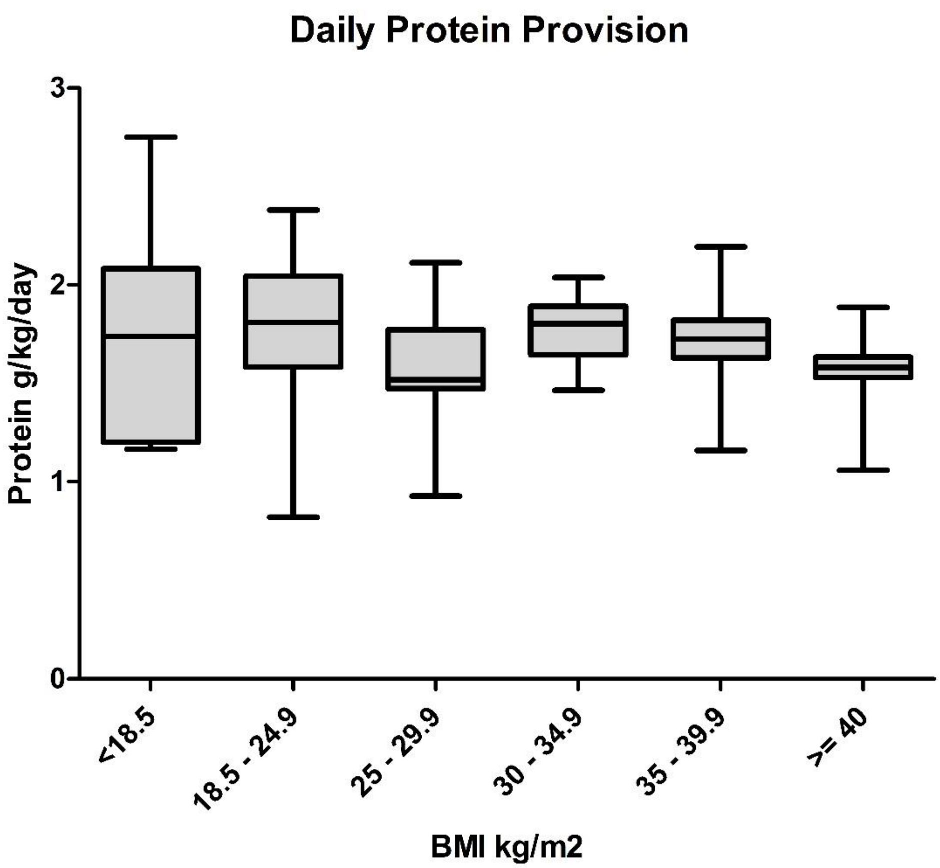


Fig.2. Daily protein provision (g/kg) BMI category.
Box = 25th and 75th percentiles, bars = 5% – 95% confidence interval
For obese subjects, provision estimates based on Adjusted Body Weight were used.

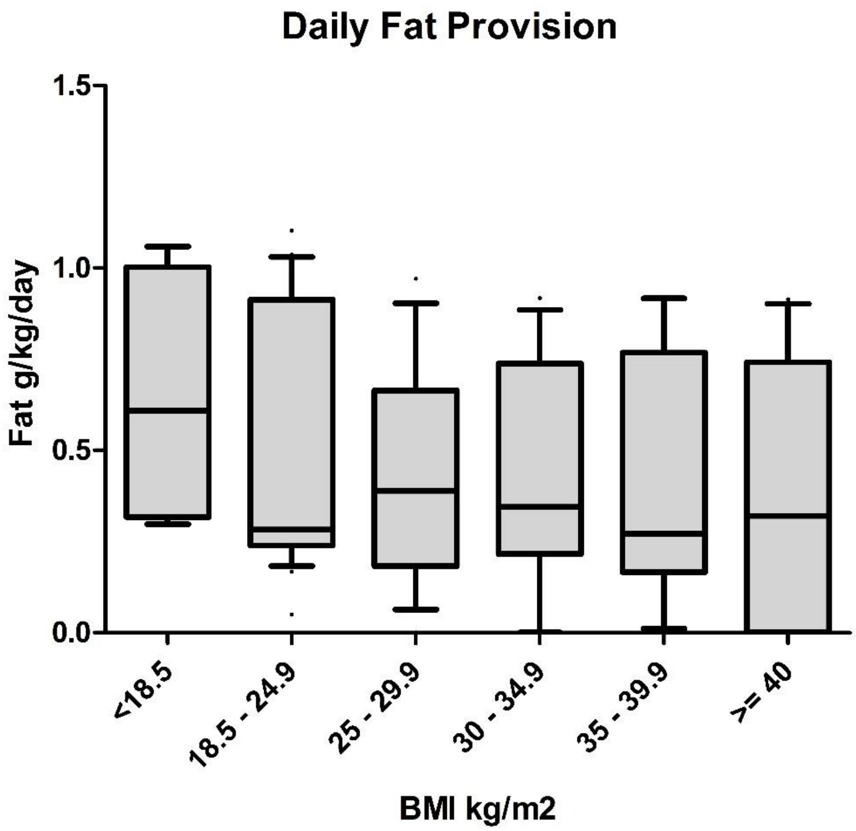


Fig.3. Estimated daily fat provision (g/kg) by BMI category.
Box = 25th and 75th percentiles, bars = 5% – 95% confidence interval
For obese subjects, provision estimates based on Adjusted Body Weight were used.

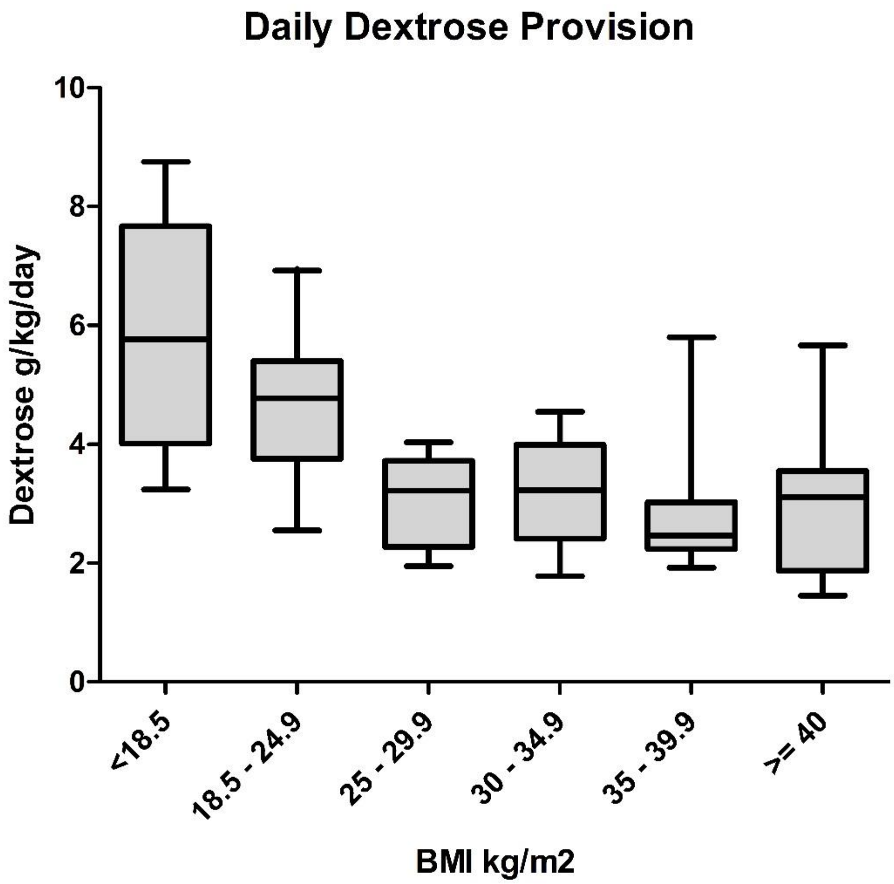


Fig.4. Daily dextrose provision (g/kg) by weight class.
Box = 25th and 75th percentiles, bars = 5% – 95% confidence interval
For obese subjects, provision estimates based on Adjusted Body Weight were used.

## BIBLIOGRAPHY


1. Colquitt JL, Pickett K, Loveman E, Frampton GK. Surgery for Weight Loss in Adults. Colquitt JL, ed. *Cochrane Database Syst Rev*. August 2014. doi:10.1002/14651858.CD003641.pub4.

2. Mechanick JI, Youdim A, Jones DB, et al. Clinical Practice Guidelines for the Perioperative Nutritional, Metabolic, and Nonsurgical Support of the Bariatric Surgery Patient-2013 Update: Cosponsored by American Association of Clinical Endocrinologists, The Obesity Society, and American Society for Metabolic Surgery. *Obesity*. 2013; 21(S1):S1-S27. doi:10.1002/oby.20461.

3. Cummings DE, Arterburn DE, Westbrook EO, et al. Gastric Bypass Surgery vs Intensive Lifestyle and Medical Intervention for Type 2 Diabetes: the CROSSROADS Randomised Controlled Trial. *Diabetologia*. 2016;59(5):945-953. doi:10.1007/s00125-016-3903-x.

4. Rubino F, Nathan DM, Eckel RH, et al. Metabolic Surgery in the Treatment Algorithm for Type 2 Diabetes: A Joint Statement by International Diabetes Organizations. *Diabetes Care*. 2016;39(6):861-877. doi:10.2337/dc16-0236.

5. Ortiz SE, Kawachi I, Boyce AM. The Medicalization of Obesity, Bariatric Surgery, and Population Health. *Health (London)*. August 2016. doi:10.1177/1363459316660858.

6. Isom KA, Andromalos L, Ariagno M, et al. Nutrition and Metabolic Support Recommendations for the Bariatric Patient. *Nutr Clin Pract*. 2014;29(6):718-739. doi:10.1177/0884533614552850.

7. Fujioka K, DiBaise JK, Martindale RG. Nutrition and Metabolic Complications After Bariatric Surgery and Their Treatment. *JPEN J Parenter Enteral Nutr*. 2011;35(5 Suppl):52S-9S. doi:10.1177/0148607111413600.

8. Aills L, Blankenship J, Buffington C, Furtado M, Parrott J. ASMBS Allied Health Nutritional Guidelines for the Surgical Weight Loss Patient. doi:10.1016/j.soard.2008.03.002.

9. Dagan SS, Keidar A, Raziel A, et al. Do Bariatric Patients Follow Dietary and Lifestyle Recommendations during the First Postoperative Year? *Obes Surg*. March 2017. doi:10.1007/s11695-017-2633-6.

10. Van Gossum A, Pironi L, Chambrier C, et al. Home Parenteral Nutrition (HPN) in Patients with Post-Bariatric Surgery Complications. *Clin Nutr*. September 2016. doi:10.1016/j.clnu.2016.08.025.

11. Mundi MS, Vallumsetla N, Davidson JB, McMahon MT, Bonnes SL, Hurt RT. Use of Home Parenteral Nutrition in Post-Bariatric Surgery-Related Malnutrition. *J Parenter Enter Nutr*. May 2016. doi:10.1177/0148607116649222.

12. Staun M, Pironi L, Bozzetti F, et al. ESPEN Guidelines on Parenteral Nutrition: Home Parenteral Nutrition (HPN) in Adult Patients. doi:10.1016/j.clnu.2009.04.001.

13. Ławiński M, Singer P, Gradowski Ł, Gradowska A, Bzikowska A, Majewska K. Predicted Versus Measured Resting Energy Expenditure in Patients Requiring Home Parenteral Nutrition. *Nutrition*. 2015;31(11-12):1328-1332. doi:10.1016/j.nut.2015.05.002.

14. Ramirez-Marrero FA, Edens KL, Joyner MJ, Curry TB. Predicted vs. Actual Resting Energy Expenditure and Activity Coefficients: Post-Gastric Bypass, Lean and Obese Women HHS Public Access. *Obes Control Ther*. 2014;1(2):1-7.

15. Marra M, Cioffi I, Sammarco R, et al. Prediction and Evaluation of Resting Energy Expenditure in a Large Group of Obese Outpatients. *Int J Obes*. February 2017. doi:10.1038/ijo.2017.34.

16. Guenter P, Robinson L, DiMaria-Ghalili RA, Lyman B, Steiger E, Winkler MF. Development of Sustain : A.S.P.E.N.'s National Patient Registry for Nutrition Care. *J Parenter Enter Nutr*. 2012;36(4):399-406. doi:10.1177/0148607111432760.

17. Winkler MF, DiMaria-Ghalili RA, Guenter P, et al. Characteristics of a Cohort of Home Parenteral Nutrition Patients at the Time of Enrollment in the Sustain Registry. *J Parenter Enteral Nutr*. May 2015:148607115586575. doi:10.1177/0148607115586575.

18. Krenitsky J. Adjusted Body Weight, Pro: Evidence to Support the Use of Adjusted Body Weight in Calculating Calorie Requirements. *Nutr Clin Pract*. 2005;20(4):468-473. http://www.ncbi.nlm.nih.gov/pubmed/16207686.

19. Pai MP, Paloucek FP. The Origin of the "Ideal" Body Weight Equations. *Ann Pharmacother*. 2000;34(9):1066-1069.

20. Young MT, Gebhart A, Phelan MJ, Nguyen NT. Use and Outcomes of Laparoscopic Sleeve Gastrectomy vs Laparoscopic Gastric Bypass: Analysis of the American College of Surgeons NSQIP. J Am Coll Surg. 2015 May;220(5):880-5. doi:10.1016/j.jamcollsurg.2015.01.059.

21. Hamilton C, Dasari V, Shatnawei A, Lopez R, Steiger E, Seidner D. Hypocaloric Home Parenteral Nutrition and Nutrition Parameters in Patients Following Bariatric Surgery. *Nutr Clin Pract*. 2011;26(5):577-582. doi:10.1177/0884533611416125.

22. Beebe ML, Crowley N. Can Hypocaloric, High-Protein Nutrition Support Be Used in Complicated Bariatric Patients to Promote Weight Loss? *Nutr Clin Pract*. 2015;30(4):522-529. doi:10.1177/0884533615591605.

23. Kumpf VJ, Slocum K, Binkley J, Jensen G. Complications After Bariatric Surgery: Survey Evaluating Impact on the Practice of Specialized Nutrition Support. *Nutr Clin Pract*. 2007;22(6):673-678. http://www.ncbi.nlm.nih.gov/pubmed/18042956.

24. Nguyen NT, Silver M, Robinson M, et al. Result of a National Audit of Bariatric Surgery

Performed at Academic Centers: a 2004 University Health System Consortium Benchmarking Project. *Arch Surg*. 2006;141(5):445-9-50. doi:10.1001/archsurg.141.5.445.

25.. Pittiruti M, Hamilton H, Biffi R, Macfie J, Pertkiewicz M. ESPEN Guidelines on Parenteral Nutrition: Central Venous Catheters (Access, Care, Diagnosis and Therapy of Complications). *Clin Nutr*. 28:365-377. doi:10.1016/j.clnu.2009.03.015.

26. Hortencio TDR, Arendt BM, Teterina A, et al. Changes in Home Parenteral Nutrition Practice Based on the Canadian Home Parenteral Nutrition Patient Registry. *J Parenter Enter Nutr*. September 2015. doi:10.1177/0148607115609289.

27. Duerksen DR, Papineau N, Siemens J, Yaffe C. Peripherally Inserted Central Catheters for Parenteral Nutrition: a Comparison with Centrally Inserted Catheters. JPEN J Parenter Enteral Nutr. 1999 Mar-Apr;23(2):85-9.

28. Choban P, Dickerson R, Malone A, Worthington P, Compher C, American Society for Parenteral and Enteral Nutrition and the AS for P and E. A.S.P.E.N. Clinical Guidelines: Nutrition Support of Hospitalized Adult Patients with Obesity. *JPEN J Parenter Enteral Nutr*. 2013;37(6):714-744. doi:10.1177/0148607113499374.

29. Owais AE, Kabir SI, Mcnaught C, Gatt M, MacFie J. A Single-Blinded Randomised Clinical Trial of Permissive Underfeeding in Patients Requiring Parenteral Nutrition. *Clin Nutr*. 2014;33(6):997-1001. doi:10.1016/j.clnu.2014.01.005.

30. Edakkanambeth Varayil J, Yadav S, Miles JM, et al. Hyperglycemia During Home Parenteral Nutrition Administration in Patients Without Diabetes. *J Parenter Enter Nutr*. September 2015:14860711560611. doi:10.1177/0148607115606116.

31. Mundi MS, Salonen BR, Bonnes S. Home Parenteral Nutrition: Fat Emulsions and Potential Complications. *Nutr Clin Pract*. 2016;31(5):629-641. doi:10.1177/0884533616663635.