PROTOCOLS FOR PERIOPERATIVE NUTRITIONAL CARE PRACTICE IN ACCREDITED BARIATRIC SURGICAL CENTERS: A SURVEY OF CURRENT PRACTICE

A thesis submitted to the
Kent State University
College of Education, Health, and Human Services
in partial fulfillment of the requirements
for the degree of Master of Science

By
Candace L. Pumper

August 2017
A thesis written by

Candace L. Pumper

B.S., Kent State University, 2014

M.S., Kent State University, 2017

Approved by

_________________________, Director, Master’s Thesis Committee
Eun-Jeong Ha

_________________________, Member, Master’s Thesis Committee
Natalie Caine-Bish

_________________________, Member, Master’s Thesis Committee
Karen Lowry Gordon

Accepted by

_________________________, Director, School of Health Sciences
Lynne E. Rowan

_________________________, Dean, College of Education, Health and Human Services
James C. Hannon
The purpose of this study was to investigate the existence of protocols available for perioperative nutritional care practice in accredited bariatric surgical centers, and determine current perioperative nutritional care practices for patients undergoing bariatric surgery. Descriptive study using an electronic survey of bariatric dietitians in accredited bariatric surgical centers. A total of 48 bariatric dietitians participated (response rate 52%). Descriptive statistics and content analysis were obtained. The majority (94.2%) felt that a standardized protocol addressing perioperative nutritional management of the bariatric population was either very important or extremely important. Respondents at 91.5% of institutions reported availability of protocols for preoperative nutrition care, and 91.5% of institutions had protocols for postoperative nutrition care. One-quarter (23.4%) reported availability of perioperative nutrition care protocols for patient-specific subpopulations. Respondents had divergent attitudes towards their institution’s current perioperative nutrition management practices. The majority (91.4%) believed they had enough knowledge of different surgical procedures to provide safe and appropriate nutrition care to their patients. Practice variation was seen among respondents for perioperative nutrition risk screening. Standardization of perioperative nutritional care protocols was universally considered important. There were written protocols available for perioperative nutrition care in the majority of surveyed institutions; however, the
content of these protocols was not standardized. Low awareness of perioperative nutrition care protocols for patient-specific subpopulations was found. The survey highlights divergences in respondents’ attitudes toward their institution’s current perioperative nutrition management practices. There are important discrepancies between surveyed respondents’ practices relative to perioperative nutrition risk screening and the available evidence.
ACKNOWLEDGEMENTS

Foremost, I would like to express my most sincere gratitude and appreciation to my committee, Dr. Eun-Jeong (Angie) Ha, Dr. Natalie Caine-Bish, and Dr. Karen Lowry Gordon for their patience, guidance and constant support throughout the time of my thesis research. Thank you from the bottom of my heart. I owe a great debt of gratitude to Dr. Nancy Burzminski, KSU Dietetic Internship Program Director, for considering me an eligible candidate for this internship. In herself, Dr. Burzminski has modeled what it is to be a dietitian and just overall better person. Her leadership, encouragement, and immense knowledge were key motivations throughout my Master of Science. I also thank Dr. David Sharp for his helpful feedback, suggestions and edits. I wish to thank all of the bariatric dietitians for giving their valuable time in responding to this survey. Thank you to Anthony Shreffler and Han Zhang for survey development assistance and statistical analysis, interpretation and organization of my data. To my parents, Dorene and Daniel Sr., I cannot thank you enough for the opportunities both of you have given me, the unwavering faith and constant encouragement as well as incredible patience over the last few years. None of this would be possible without you. I hope I have made you proud. And to my sister, Deanna, a huge thank you for your continued friendship, support, laughs, cups of coffee and snacks along the way, and for always inviting me to take a break and spend the afternoon with my niece and nephew. Finally, my thanks and appreciation go to my brother, Daniel Jr., and to my grandparents. I love you dearly.

iv
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ACKNOWLEDGEMENTS</td>
<td>iv</td>
</tr>
<tr>
<td></td>
<td>LIST OF FIGURES</td>
<td>ix</td>
</tr>
<tr>
<td></td>
<td>LIST OF TABLES</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>CHAPTER</td>
<td></td>
</tr>
<tr>
<td>I.</td>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Statement of the Problem</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Purpose Statement</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Research Question</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Operational Definitions</td>
<td>5</td>
</tr>
<tr>
<td>II.</td>
<td>REVIEW OF THE LITERATURE</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Obesity</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Epidemiology</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Global trends in obesity</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Trends in obesity in the United States</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Classification of Obesity</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Measurements of Adiposity and Body Composition</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Measurements of BMI, waist circumference, and waist-to-hip ratio</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Skinfold thickness</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Bioelectrical impedance analysis</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Underwater (hydrostatic) weighing</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Medical imaging procedures</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Computed tomography</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Magnetic resonance imaging</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Ultrasound imaging</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Dual-energy x-ray absorptiometry</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Etiologies of Obesity</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Genetics of obesity</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Environment and obesity</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Stress-induced obesity and sleep deprivation</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Alcohol consumption, weight gain, and obesity</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Pharmaceutical iatrogenesis and obesity</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Other causes of obesity</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Pathophysiology of Obesity</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Regulation of food intake and energy homeostasis</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Central control of energy homeostasis</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Obesity-Related Comorbidities and Mortality</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Type 2 diabetes mellitus</td>
<td>24</td>
</tr>
</tbody>
</table>
Medical Clearance ................................................................. 89
Preoperative Nutrition Care .................................................. 94
Preoperative nutrition risk screening and stratification .......... 94
Preoperative micronutrient supplementation ....................... 95
Preoperative diet regimens ..................................................... 96
Preoperative weight loss requirements .................................. 97
Postoperative Nutrition Care .................................................. 98
Postoperative nutritional management .................................... 98
Laboratory monitoring ........................................................... 99
Postoperative diet stages and progression ............................... 99
  Postoperative days 1 and 2 .................................................. 100
  Stage II discharge diet – full liquids .................................... 101
  Stage III pureed diet .......................................................... 102
  Stage IV mechanically-altered soft diet ............................... 103
  Stage V regular foods (maintenance) .................................... 103
Postoperative nutrient requirements ...................................... 104
  Energy (calorie) requirements ............................................. 104
  Protein requirements .......................................................... 105
  Carbohydrate and lipid (fat) requirements ............................ 107
  Fluid requirements ............................................................... 108
Micronutrient supplementation ............................................. 108
  Thiamin (vitamin B1) ........................................................... 109
  Cobalamin (vitamin B12) ....................................................... 110
  Folate ................................................................................. 111
  Iron .................................................................................... 112
  Vitamin D and calcium ....................................................... 114
  Vitamin A ........................................................................... 116
  Copper and zinc ................................................................. 117
Postoperative follow-up ......................................................... 119

III. METHODOLOGY .................................................................. 121
  Study Design and Sample .................................................... 121
  Survey Development ............................................................. 122
  Procedures ............................................................................ 122
  Statistical Analysis ................................................................. 123

IV. RESULTS .............................................................................. 124
  Demographic Characteristics of Surveyed Respondents ........ 124
  Characteristics of Accredited Centers of Surveyed Respondents 124
  Self-Perceived Importance of Standardization of Perioperative Nutritional Management Among Bariatric Dietitians 125
  Bariatric Dietitians’ Attitudes Towards Facility-Based Perioperative Nutrition Management Practices 128
  Self-Reported Knowledge of Bariatric Surgical Procedures Among Bariatric
Reported Availability of Protocols for Perioperative Nutritional Care in Accredited Centers .......................................................... 129
Perioperative Nutrition Risk Screening Practices Among Multidisciplines and Bariatric Dietitians in Accredited Centers .......................................................... 133
Self-Reported Perioperative Nutrition Assessment Practices Among Bariatric Dietitians .......................................................................................... 134
Self-Reported Nutritional Strategies Used by Bariatric Dietitians to Prepare Candidates for Bariatric Surgery .......................................................... 136
Preoperative Patient Education Practices in Accredited Centers and Among Bariatric Dietitians .......................................................................................... 138
Diet instructions Introduced to Patients Before Discharge by Bariatric Dietitians .......................................................... 140
Self-Reported Postoperative Nutritional Monitoring Practices Among Bariatric Dietitians .......................................................................................... 141
Multidisciplinary Team Approach in Bariatric Surgery .......................................................................................... 142
Health care provider involvement in postoperative patient education .......................................................... 142
Responsible health care provider for preoperative and postoperative laboratory test orders .......................................................................................... 143

V. DISCUSSION .......................................................................................................................... 145
Limitations of the Current Study .......................................................................................... 157
Implications for Clinical Practice .......................................................................................... 158
Conclusion .......................................................................................................................... 159

APPENDICES .......................................................................................................................... 161
APPENDIX A: MEDICAL DIRECTOR AND PROGRAM COORDINATOR LETTER .......................................................................................... 162
APPENDIX B: INVITATION EMAIL TO BARIATRIC REGISTERED DIETITIANS .......................................................................................... 164
APPENDIX C: REMINDER EMAIL TO NON-RESPONDERS .......................................................................................... 167
APPENDIX D: INFORMED CONSENT .......................................................................................... 169
APPENDIX E: SURVEY .......................................................................................................................... 172
APPENDIX F: ADDITIONAL DATA SET .......................................................................................... 195

REFERENCES .......................................................................................................................... 208
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Regional Trend in Bariatric Surgery, 2003-2013 for United States/Canada</td>
<td>40</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Postoperative Vitamin Supplementation Recommendations by Surgery Type, LRYGB vs. LSG</td>
<td>119</td>
</tr>
<tr>
<td>2. Demographic Characteristics of Bariatric Dietitian Survey Respondents (n=47)</td>
<td>125</td>
</tr>
<tr>
<td>3. Characteristics of MBSAQIP-Accredited Centers of Surveyed Bariatric Dietitians (n=47)</td>
<td>127</td>
</tr>
<tr>
<td>4. Availability of Protocols for Perioperative Nutritional Care in MBSAQIP-Accredited Centers as Reported by the Surveyed Bariatric Dietitians (n=47)</td>
<td>130</td>
</tr>
<tr>
<td>5. Reported Components of Perioperative Nutritional Care Protocols as Reported by the Surveyed Bariatric Dietitians</td>
<td>132</td>
</tr>
<tr>
<td>7. Self-Reported Perioperative Nutrition Assessment Practices Among Surveyed Bariatric Dietitians</td>
<td>135</td>
</tr>
<tr>
<td>8. Self-Reported Preoperative Nutritional Strategies Used by the Surveyed Bariatric Dietitians to Prepare Candidates for Bariatric Surgery</td>
<td>137</td>
</tr>
<tr>
<td>10. Diet Instructions Introduced to Patients Before Hospital Discharge as Reported by the Surveyed Bariatric Dietitians</td>
<td>140</td>
</tr>
<tr>
<td>11. Self-Reported Postoperative Nutritional Monitoring Practices Among Surveyed Bariatric Dietitians (n=42)</td>
<td>141</td>
</tr>
<tr>
<td>12. Involvement of Health Care Provider in the Postoperative Education of Dietary Guidelines, Meal Progression, Multivitamin-Mineral Supplementation Regimen as Reported by the Surveyed Bariatric Dietitians</td>
<td>143</td>
</tr>
</tbody>
</table>
13. Responsible Health Care Provider for Preoperative and Postoperative Laboratory Test Orders as Reported by the Surveyed Bariatric Dietitians (n=48) ..................144

14. Practice of Routine Preoperative Micronutrient Supplementation Regimens Among MBSAQIP-Accredited Centers and Self-Reported Timing of Initiating of Multivitamin-Mineral Supplementation After Hospital Discharge for Postoperative Patients by Surveyed Bariatric Dietitians (n=41) ..................197

15. Frequencies of Testing for Routinely Recommended (First-Line) Laboratory Tests for Each Surgery Type (n=48) ..........................................................199

16. Frequencies of Testing for Second-Line Laboratory Tests for Each Surgery Type (n=48) ..........................................................202

17. Routine Procedures for Postoperative Follow-up Care in MBSAQIP-Accredited Centers as Reported by the Surveyed Bariatric Dietitians ..................206

18. Health Care Provider Responsible for the Evaluation of Diet Tolerance and Advancement of Diet During the Postoperative Period as Reported by the Surveyed Bariatric Dietitians (n=48) ..........................................................207
CHAPTER I

INTRODUCTION

Obesity is a rapidly growing health problem and is likely to represent a significant financial burden to the public healthcare system in most countries (Stienstra et al., 2007). Morbid obesity is considered the most serious stage of the disease, with a population prevalence of six to eight percent in the United States (Fryar et al., 2012). Management of morbid obesity through lifestyle, pharmacological, or surgical interventions has been described in the literature (Behary & Kumbhari, 2015; Gloy et al., 2013; Li et al., 2005; Wadden et al., 2005). Diet and exercise themed management requires significant discipline and many morbidly obese individuals may find it difficult to instigate and maintain a consistent regimen (Espeland, 2007; Glandt & Raz, 2011; Gloy et al., 2013; Ryan et al., 2010; Sjöström et al., 2004; Wadden et al., 2012). Pharmacologic therapy offers a possible adjunct when weight loss is not achieved through diet and exercise alone; however, its impact is modest and is limited by side effects, contraindications, and compliance rates (Glandt & Raz, 2011; Kaukua et al., 2003; Li et al., 2005; Moyers, 2005; Wadden et al., 2005). Surgical intervention traditionally is recommended only as medically necessary and it acts as an ancillary measure when patients whose body mass index (BMI) is $\geq 40 \text{ kg/m}^2$ or those with BMI $\geq 35 \text{ kg/m}^2$ with obesity-related comorbidities fail diet, exercise, and drug therapy (Mechanick et al., 2008; 2013).

Bariatric surgery provides a durable and effective method of treating morbid obesity and related diseases, and the demand for this surgery is growing nationwide
(Adams, et al., 2007; Bray, 2008; Buchwald et al., 2004; Carlin et al., 2013; Courcoulas et al., 2014b; Gloy et al., 2013; Kohn et al., 2009; Maggard et al., 2005; Mechanick et al., 2013; Nguyen et al., 2011; Padwal et al., 2011; Porjes et al., 1987; Schauer et al., 2003; Scopinaro et al., 2005; Serrano et al., 2015; Sjöström et al., 2004, 2007). Given that demand for bariatric surgery increases as expected, strategies need to be implemented aimed at optimizing perioperative care; to ensure efficiency and optimize outcomes. The Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP), a joint program of the American College of Surgeons (ACS) and the American Society for Metabolic and Bariatric Surgery (ASMBS), is the only nationally validated outcomes-based program to measure and compare the quality and safety for metabolic and bariatric surgical care in the United States and Canada. In 2016, the ACS and ASMBS published its updated MBSAQIP Standards for optimal care of the metabolic and bariatric surgery patient (ACS & ASMBS, 2016). The Standards provide a nationally consistent and uniform set of measures of safety and quality for application in bariatric surgery care throughout the perioperative period (ACS & ASMBS, 2016).

Under the Standards, both the ACS and ASMBS require established perioperative protocols that facilitate standardization of care related to the bariatric surgical procedure. In addition, the ACS and ASMBS require the use of comprehensive protocols that outline the continuum of care of the bariatric surgery patient. Protocols are formal pathways that integrate evidence-based recommendations and algorithms for a specific patient population with a predictable clinical course (Prasad et al., 2010). Protocols might be particularly helpful in bariatric surgery because they can define, optimize, and sequence
different tasks performed by members of the multidisciplinary team (ACS & ASMBS, 2016). The multidisciplinary team includes surgeons, anesthesiologists, nurses, psychologists, dietitians, and medical subspecialties as clinically indicated. The implementation of protocols for use in the perioperative care has been associated with improved outcomes in bariatric surgery patients and significant savings to the health-care system (Campillo-Soto et al., 2008; El Chaar et al., 2014; Frutos et al., 2007; Huerta et al., 2001; Yeats et al., 2005).

Published protocols and algorithms on perioperative care in bariatric surgery remain limited (Campillo-Soto et al., 2008, Frutos et al., 2007; Huerta et al., 2001; Yeats et al., 2005). Several national and international organizations and societies have compiled the available evidence into management guidelines since 2005 (Fried et al., 2007, 2013; Heber et al., 2010; Mechanick et al., 2008, 2013; NICE, 2016; SAGES, 2008; Sauerland et al., 2005). Mechanick et al. (2008, 2013) have previously proposed a set of guidelines for optimal perioperative care of bariatric patients. A major challenge to these guidelines relates to their graded levels of evidence strength. As there are a lack of formal guidelines, protocols for the perioperative care of the bariatric surgery patient are mainly institution specific (Eldar et al., 2011).

**Statement of the Problem**

Management targeted solely at care for patients with obesity is a challenge unto itself. This is especially true when incorporating the added demands of compensating for a surgically altered gastrointestinal anatomy (Isom et al., 2014). In all phases of care, clinicians must be prepared to manage the bariatric surgery population. Nutritional
depletion is pervasive in preoperative candidates and is a well-recognized complication of bariatric surgery (Aills et al., 2008; Ben-Porat et al., 2015; Mechanick et al., 2013; Peterson et al., 2016). Medical nutrition therapy and the practice of the nutrition care process, including methods of screening/assessment, diagnosis, intervention, and monitoring and evaluation, is increasingly regarded as an essential part of comprehensive perioperative care of the bariatric surgery patient.

The bariatric dietitian has an increasing important role in the management of the bariatric surgery patient before and after surgery. Studies demonstrating improved clinical outcomes in retrospective studies, coupled with the expanding roles of dietitians in bariatric surgery care, emphasizes the importance of dietitian involvement in the bariatric surgery population (Coltman et al., 2015; Lavertue & Salgueiro, 2012; Rachal et al., 2015). Bariatric dietitians provide preoperative nutrition education and consultation to prepare candidates for successful surgery, counsel postoperative patients to ensure dietary compliance and nutritional adequacy, comprehensively address their patients’ nutrient needs, assess and adjust postoperative diet regimens according to diet tolerance and weight changes, and monitor micronutrient supplementation. Bariatric dietitians’ knowledge and skills can have potential to improve weight loss outcomes and facilitate patient adherence (Beckman & Earthman, 2013).

Evidence-based guidelines for perioperative care in bariatric surgery are useful in supporting clinical decisions and evidence-based guidelines specific to the perioperative nutritional care of patients undergoing bariatric surgery are available (Aills et al., 2008; Mechanick et al., 2008, 2013). The extent of their availability in accredited bariatric
surgical centers across the United States is unclear. Gaps between recommendations from such guidelines and actual nutrition practice among bariatric dietitians have also been described. The last evaluation of bariatric nutrition practice in US ASMBS-recognized accredited centers was published in 2010 (Wical et al., 2010).

**Purpose Statement**

The purpose of this study was to investigate the existence of protocols available for perioperative nutritional care of patients undergoing bariatric surgery in accredited centers, and determine current perioperative nutritional care practices for patients undergoing bariatric surgery.

**Research Questions**

1. What proportion of accredited MBSAQIP centers in the United States have protocols for perioperative nutritional care of patients undergoing bariatric surgery?

2. What are the current perioperative nutritional care practices in patients undergoing bariatric surgery?

**Operational Definitions**

**Perioperative:** “The time periods immediately before (preoperative), during (intraoperative), and after (postoperative) a surgical operation” (The U.S. National Library of Medicine, n.d.).

**Nutritional care practice:** Procedures involved in ensuring appropriate nutrition screening/assessment, diagnosis, intervention, and monitoring/evaluation, especially for the bariatric surgery patient.
Protocol: “Sequence of orders and therapies describing the routine care of the metabolic and bariatric patient from initial evaluation through long-term follow-up” (ACS & ASMBS, 2016).

Bariatric surgery: Surgical procedure of the stomach or intestines to induce significant and durable weight loss and improve obesity-associated morbidity and mortality.

**Laparoscopic Roux-en-Y gastric bypass:** A combination restrictive and malabsorptive surgical technique that involves the creation of a small, 15 to 30 mL stapled gastric pouch just past the gastroesophageal junction, followed by end-to-end gastrojejunal anastomosis accompanied by a bypass of the remaining stomach, duodenum, and proximal jejunum, resulting in malabsorption of food (Mechanick et al., 2008, 2013; Neff et al., 2013; Sahebzamani et al., 2013).

**Laparoscopic sleeve gastrectomy:** A restrictive bariatric procedure in which 80% or more of the stomach is removed along the greater curvature, leaving a tubular gastric remnant of reduced size (approximately 60 to 150 mL in capacity), thereby restricting food intake (Biter et al., 2015; Chambers et al., 2012; Gadiot et al., 2011; Karmali et al., 2010).
CHAPTER II
REVIEW OF LITERATURE

Obesity

Obesity, most defined as a state of low-grade inflammation accompanied by excess fat deposited in tissues including adipose tissue, liver, and muscle, is a rapidly growing health problem and is likely to represent a significant financial burden to the public health care system in most countries (Stienstra et al., 2007). Tsai et al. (2011), using National Health Expenditure Accounts data reported that incremental cost of obesity totaled $1,723 in 2008. Estimates of $Y2008 aggregate costs of overweight and obesity combined totaled $113.9 billion, or 4.8% of United States healthcare spending (Tsai et al., 2011). Indeed, the financial burden of obesity is substantial in the United States and expected to increase in the future due to expected population growth and gaining, as well as trends in treatment patterns and health care and medical costs following diagnosis of obesity and related health problems. Finkelstein et al. (2012) issued their projection for the year 2030’s combined obesity-related medical expenditure based on trends in United States health care spending and recent statistics of obesity prevalence of the American adult population (shown elsewhere in this review). Projected saving for medical expenditure is estimated to reach $549.9 billion (Finkelstein et al., 2012).

Epidemiology

The following describes epidemiological trends in obesity at the global and national scale.
**Global trends in obesity.** Global prevalence of obesity has risen dramatically over the past two decades according to recent World Health Organization (WHO) global estimates. In 2014, the most recent year of data from the WHO, the number of adults aged 18 years and older who were overweight (BMI ≥ 25.0 kg/m²) was more than 1.9 billion (39%), and of these, more than 600 million were obese (13%) (WHO, 2015).

Among world regions, there is great variability in prevalence of overweight and obesity. Differences in income across countries are much greater, as populations in high income countries weighed six times as much as those populations in low and lower middle-income countries (WHO, 2015). Dramatic increases in overweight and obesity prevalence are primarily centered in low- and middle-income countries (WHO, 2015). This unprecedented trend is due to global trade liberalization, economic growth, rapid urbanization that coincides with shifts in feeding practices and energy expenditure, and reductions in physical activity (Alouki et al., 2015; Malik et al., 2013; Nguyen & El-Serag, 2010).

Observations suggest substantial discordance in prevalence of overweight and obesity by geographic region as assessed by WHO global health estimates. Regions of the Americas (e.g., United States of America; Mexico; Canada; Brazil) had the highest prevalence of overweight and obesity, reporting 61% for overweight and 27% for obesity according to Global Health Observatory (GHO) data. Conversely, Regions for South East Asia (e.g., India; Indonesia; South Korea) had among the lowest prevalence of overweight and obesity according to GHO data. Regions for South East Asia reported a prevalence rate of 22% for overweight and 5% for obesity (WHO, n.d.).
**Trends in obesity in the United States.** The prevalence of adult obesity in the United States, as depicted by the National Health and Nutrition Examination Survey (NHANES), continues to grow, though at a slower pace than previously seen. Obesity has become a leading public health issue nationally, with estimated 78.6 million in 2012 (CDC, 2015; Ogden et al., 2014). This figure represents a two-fold increase in the past three decades. Data from NHANES, 2013-2014, showed that the prevalence of obesity (defined as a BMI of 30 or greater) in the United States had increased by approximately seven percentage points after being relatively stable from 1999-2000 and 2001-2002 (Flegal, et al. 2002; Ogden et al., 2015). NHANES data showed a prevalence of obesity of 30.5% during 1999 to 2002, and an estimate of 37.7% for 2013 to 2014. Data also indicated increasing trends in incidence of class III obesity, defined as a BMI of 40 or greater, among adults. Approximately four percent of men and eight percent of women, when reported by NHANES in 2009-2010, were considered extremely obese (Fryar et al., 2012).

Nationwide prevalence is expected to continue to rise, with numbers projected to reach 164 million adults (42%) by the year 2030, representing a 33% increase from 2010 (Finkelstein et al., 2012; Trippel, 2015). Projections for severe obesity based on linear time trends suggest a 130% increase in prevalence over the next 20 years (Finkelstein et al., 2012).

Nationwide, the proportion of adults with a BMI of 30 kg/m² or greater increased between 1999 and 2014 from 27.5% to 34.3% in men, and from 33.4% to 38.3% in women (Flegal, et al. 2002; Ogden, et al., 2015). Trends in obesity over the 16 years of
NHANES survey cycles demonstrated that obesity prevalence is variant across demographic groups. Among men, obesity prevalence ranged from 23.7% to 38.3%; within racial and ethnic groups, prevalence ranged from 11.2% among Non-Hispanic Asian men to 39.0% among Hispanic men. For women, obesity prevalence ranged from 28.4% to 42.1%; within racial and ethnic groups, prevalence ranged from 11.9% among Non-Hispanic Asian women to 56.9% Non-Hispanic black women (Ogden et al., 2015).

Classification of Obesity

Body mass index (BMI), the ratio of weight in kilograms divided by height in meters squared is conventionally used for classification of obesity (Bouret et al., 2015). Three classes of obesity have been described: Class I (defined as BMI of at least 30.0 kg/m²), Class II (severe obesity defined as BMI between 35.0 and 39.9 kg/m²), and Class III (morbid obesity defined as BMI of 40.0 kg/m² or greater).

Measurements of Adiposity and Body Composition

BMI, waist circumference, waist-to-hip ratio, skinfold thickness, bioelectrical impedance analysis, underwater (hydrostatic) weighing and medical imaging procedures (such as in computed tomography (CT), magnetic resonance imaging (MRI) and dual-energy x-ray absorptiometry (DEXA) scan), are all common diagnostic tests used to screen for overweight or obesity. The diagnostic screening tools and imaging exams are provided below.

Measurements of BMI, waist circumference, and waist-to-hip ratio. BMI, waist circumference and waist-to-hip ratio are three measures of obesity. “BMI is a measure of weight adjusted for height, calculated as weight in kilograms divided by the
square of the height in meters” (CDC, 2011; Xu et al., 2015). BMI is effective for the
assessment of general obesity and disease risk for populations (Borecki et al., 1998) but
also has limited value in differentiating “lean versus adipose tissue compartments” (Prado
et al., 2015). The thing about this index is that it only accounts for height and body
weight. Great for assessing patients who have a BMI above 30 kg/m^2 and/or who are
participating in a weight loss program, but hard on estimating body composition and
body fat distribution (CDC, 2011). This is affected by a number of factors, including the
age, gender, ethnicity, and muscle mass of the patient (CDC, 2011). However, despite
the limitation, BMI continues to be used to screen for obesity risk. For prospective
bariatric surgery patients, BMI is an excellent tool to determine eligibility.

Waist circumference and circumference measurements of the waist and hips also
provide an index of body fat distribution. Waist circumference and waist-to-hip ratio are
anthropometric measures of obesity for central subcutaneous adipose tissue distribution.
Central obesity measured by either waist circumference or waist-to-hip ratio, have been
implicated in the development of chronic disease. These measurements are better
predictors of disease risk than BMI. In the Caucasian population, standard cut-off points
for defining central obesity are >102 centimeters (>40 inches) for men, and >88
centimeters (>35 inches) for women.

**Skinfold thickness.** Skinfold thickness is a cost-effective and accessible
alternative to laboratory imaging methods - computed tomography (CT), magnetic
resonance imaging (MRI), ultrasound, and dual-energy x-ray absorptiometry (DEXA) -
for determining body composition. It is a valuable tool in the assessment of fold
thick
ness, but not tissue thickness (Wagner, 2013). The assessment of body composition involves measurement of anatomic landmarks at five distinct sites: triceps, subscapula, suprailiacl, abdomen, and thigh. Additional sites include the pectoral, midaxillary, and calf. The advantages of this approach are low expense, quick measurements, minimal storage space required for equipment, noninvasive, and reasonably accurate prediction of percentage body fat (Rosenbloom & Coleman, 2012). Skinfold thickness measurements are frequently impractical in obese individuals. The estimation of body fat percentage in obese individuals is a difficult task due to variation in depth of caliper placement, variation in adipose tissue compressibility, and reduction in inter-rater reliability (Wagner, 2013).

**Bioelectrical impedance analysis.** Bioelectrical impedance analysis or BIA is a non-invasive technique for the evaluation of body composition that relies upon conductive properties of body tissues and electrical current (Rosenbloom & Coleman, 2012). With application of electrical current, BIA can be used to measure percent body fat. BIA relies upon the basic principle of “resistance of electrical current due to differences in water content of fat and lean tissue” (Rutherford et al., 2011). Lean tissue contains high levels of water and electrolytes and acts as a conductor of an electrical signal. Fat tissue (fat mass) comparatively is anhydrous and restricts the flow of electrical signals (Rutherford et al., 2011). High bioelectrical impedance measures have a direct relationship with increased fat mass and higher levels of body fat (Rutherford et al., 2011). Although BIA is limited by hydration status, its variability in fat and fat-free mass estimates, and its “accuracy in [persons] with disproportionately high
concentrations of water in fat-free mass; amputees; and those suffering from unilateral hemiparesis, edema, or tissue atrophy” (Rosenbloom & Coleman, 2012), it is the preferred field method (versus skinfold measurements) to estimate percent body fat, especially in obese individuals (Rutherford et al., 2011). Of note, however, BIA values may not be as accurate in this population.

**Underwater (hydrostatic) weighing.** Underwater (hydrostatic) weighing is an advanced technique for estimating fat- and fat-free mass composition and density in the general population (Rosenbloom & Coleman, 2012). It is a densitometric technique that assumes that fat-free mass density is relatively stable (Rosenbloom & Coleman, 2012). Underwater weighing is based on Archimedes’ principle, which states that a submerged object exerts an upward buoyant force equal to the weight or volume of the fluid displaced (Rosenbloom & Coleman, 2012). Fat mass is more dense and its weight is less than the buoyant force, causing the submerged object to float. Fat-free mass comparatively is less dense and its weight is greater than the buoyant force, causing the submerged object to sink. Increasing levels of fat-free mass result in a lower buoyant force, and corresponds to a higher body weight when submerged in water (Rosenbloom & Coleman, 2012).

Underwater weighing can provide acceptable accuracy and reliability in measuring body composition. However, the utility of underwater weighing is limited due to the cost of the equipment, lack of portability, trained personnel required, its subject limit, discrepancies of measured lung volumes, and its inability to measure abdominal gas volume (Gropper & Smith, 2012). These criteria combine to limit the availability of this
technique in most settings, especially those that are community-based (Gropper & Smith, 2012). Because this technique requires partial or complete submersion under four to five feet of water, it may be difficult to achieve participant compliance. This technique is not recommended for assessing children, obese or elderly individuals, and individuals in poor health.

**Medical imaging procedures.** Computed tomography (CT), magnetic resonance imaging (MRI), ultrasound and dual-energy x-ray absorptiometry (DEXA) scan are imaging “procedures with either a diagnostic or therapeutic purpose” (Lutz & Buscarini, 2011).

**Computed tomography.** CT scanning is a noninvasive and accurate imaging technique for measuring regional body fat distribution and body density, and in addition, distinguishing trabecular and cortical bones (Gropper & Smith, 2012). X-rays are used to create cross-sectional, detailed images of internal organs, soft tissue, and bones. Effective in assessing body composition at the tissue-organ level and estimating whole-body composition, but not safe for repeated measures. The problem is that CT imaging exposes patients to ionizing radiation (Gropper & Smith, 2012). A comparable imaging technique without this exposure is magnetic resonance imaging (MRI).

**Magnetic resonance imaging.** Low-field images from MRI scanners can be used for detection of brain tumors and structural abnormalities, and evaluation of muscle hydration and fat content and distribution (Gropper & Smith, 2012). The MRI to estimate regional and whole-body connective, muscular, and nervous tissue is based on hydrogen nuclei interactions and magnetic gradients generated by magnetic resonance
instruments (Rosenbloom & Coleman, 2012). MRI requires no radiation exposure and can provide accurate and reliable estimates of body composition. However, equipment is expensive, limited availability, and tedious and time-consuming processing procedures limits its utility in clinical research (Rosenbloom & Coleman, 2012). It is not a commonly used procedure for obese individuals.

**Ultrasound imaging.** Ultrasound permits imaging of tissue configurations and gives information about changes in tissue (e.g., skin-subcutaneous fat; fat muscle; muscle bone) density and thickness (Lukaski, 1987; Wagner, 2013). It is a well-established technique with advantages that include low costs (versus other laboratory methods), high accuracy and precision, noninvasive imaging modalities, no ionizing radiation, minimal tissue compression, ability to discriminate visceral from subcutaneous adipose tissue, wide availability, portability, and shorter testing time (Lutz & Buscarini, 2011; Wagner, 2013). Ultrasound operates at frequencies between 3 and 30 MHz, depending on the site of measurement (Lutz & Buscarini, 2011). The mechanics of ultrasound have been elucidated. In broad terms, ultrasound “visualize structural details by converting acoustic impedance of soft tissue into an ultrasonographic image” (Lin et al., 2016). Ultrasound may be difficult in obese, especially morbidly obese patients because reflected signals are often distorted and weakened.

**Dual-energy x-ray absorptiometry.** DEXA is highly accurate for diagnosing osteoporosis and osteopenia. In addition, DEXA currently provides a precise approach to assess regional and whole-body composition in terms of fat and fat-free mass in a noninvasive way, in three main fields of research: nutrition, metabolism, and bone
physiology (Rosenbloom & Coleman, 2012). Dual-energy systems generate x-rays at two different energies and make use of the attenuation and differential signals made available by energies of the x-ray beams (Gropper & Smith, 2012). The differential attenuation of x-ray beams is used in calculations of bone mineral content and soft tissue composition (Rosenbloom & Coleman, 2012). Common measurement sites include lumbar spine, proximal femur, and forearm. Radiation exposure incurred during DEXA scanning is minimal and thus is a safe technique. The procedure for DEXA scanning is relatively simple and quick.

Precision of DEXA measurements are generally excellent; coefficients of variation are about 1% for spine and bone mineral content and 2 to 3% for total body fat (de Lorenzo et al., 1998; Laskey, 1996). Precision is best for collegiate athletes and healthy individuals. Precision errors are greater for osteoporotic and obese patients (Gropper & Smith, 2012; Rosenbloom & Coleman, 2012). Common sources of error and uncertainty in DEXA measurements include scanner calibration, inherent artifacts (metal implants – pins or rods; clothing), photon and electronic noise, isotope interferences, changes in soft tissue composition, and patient positioning and scan analysis (Larkin, n.d.). Like underwater weighing, the utility of DEXA is limited due to expense of the equipment, lack of portability, licensed x-ray technician required, its weight limit, and discrepancies of measured bone and soft tissue values due to differences in scanner calibration, bone edge detection algorithms, or presence of compression fractures, osteoarthritis, or other factors that affect bone health (Laskey, 1996).
Etiologies of Obesity

The following describes the various etiologies of obesity.

**Genetics and obesity.** Familial, twin, and adoption studies provide evidence for heritability of obesity (Borecki et al., 1998; Davey et al., 2000; Fabsitz et al., 1994; Hebebrand et al., 2000; Hsueh et al., 2000; McQueen et al., 2003; Rice et al., 1997, 1999; Schousboe et al., 2004; Stunkard et al., 1986a, 1986b). In the last two decades, the genetic determinants of obesity have been unrevealed using candidate gene, genome-wide linkage and genome-wide association studies (GWAS) (Blakemore & Froguel, 2010; Fawcett & Barroso, 2007; Herbert et al., 2006). The latter GWA approach has been successful in identifying genetic loci and specific genetic variants in common forms of obesity. GWAS efforts have identified more than 50 loci associated with obesity susceptibility to date (Herrera et al., 2011). Taken together, the identified loci have been estimated to explain 40% to 80% of the inherited variation, or the heritability in body mass within a population (Herrera et al., 2011). These genetic variants often act in concert with environmental, behavioral/psychological, and social stressors that influence food intake, nutrition, and health.

Single nucleotide polymorphisms (SNPs) in the first intron of *FTO* (fat mass and obesity-associated) gene have been unequivocally confirmed as conferring susceptibility to obesity (Frayling et al., 2007; Herrera et al., 2011). The *FTO* gene, which is most highly expressed in the brain – particularly the hypothalamus, which plays a key role in the control of both energy and glucose homeostasis – maps to chromosome 16. The *FTO* gene is a large protein containing nine exons and the genomic DNA encoding *FTO* spans...
a region of more than 400 kb (Loos & Bouchard, 2008). The intron/exons structures are highly conserved and the SNPs identified are strongly associated with obesity-related traits and higher obesity risk (Dina et al., 2007; Frayling et al., 2007; Liu et al., 2008; Loos & Bouchard, 2008; Meyre et al., 2009; Scherag et al., 2010; Scuteri et al., 2007; Thorleifsson et al., 2009). Combined, the FTO region explains approximately 1% of the variance in BMI and approximately 20% of the population attributable risk for obesity (Frayling et al., 2007). Frayling and colleagues (2007) reported a strong association of the rs9939609 A-allele, a variant residing at the FTO locus, with obesity risk in populations of White/European descent. It was reported that adults carrying the risk allele compared with those not inheriting a risk allele weighed on average two to three kilograms more and had 1.67-fold increased odds of obesity (Frayling et al., 2007). Meta-analysis of GWAS in some Asian-ancestry populations as well as Canadians of South Asian origin, Inuit, Pakistani, and Hispanic-American populations, demonstrate associations between polymorphisms in the FTO gene and BMI/obesity; data is less conclusive for African-Americans (Hennig et al., 2009; Shabana & Hasnain, 2015).

**Environment and obesity.** Many aspects of the environment influence obesity, including the globalization of the food industry, advertising/marketing agencies and communication technologies, the decline in agricultural self-sufficiency and rise in global agribusiness and transnational food companies, limited access to full-service supermarkets, the displacement of local food retails and entry of convenience stores, the effects of the nutrition transition (shifts in the structure of the diet) due to rapid urbanization, dietary convergence and adaptation to a Western diet, increased availability
of energy-dense foods, the accelerated development of new technologies, reductions in physical activity and increases in sedentary behavior, and increases in knowledge-based work (Dixon et al., 2007; Hawkes, 2006; Huneault et al., 2011; McMichael, 2004). Looming in the background as additional determinants of obesity are disparities in wealth, macroeconomic conditions, culture, education (e.g., less physical education in schools), and language barriers (Hawkes, 2006; Lovasi et al., 2009; Sallis & Glanz, 2009).

**Stress-induced obesity and sleep deprivation.** Obesity has also been suggested to be the consequence of chronic stress exposure and sleep deprivation (Epel et al., 2001; Speigel et al., 2004). Epel and colleagues (2001) suggest that chronic stress-induced cortisol exposure may impair hypothalamic-pituitary-adrenal (HPA) axis activity, thus impeding central regulation of food intake. The work described by Speigel et al. (2004) suggests that short sleep duration decreases circulating leptin levels, increases ghrelin levels, and increases appetite, particularly for calorically dense foods with high carbohydrate content (Speigel et al., 2004).

**Alcohol consumption, weight gain, and obesity.** Other aspects of environmental influence obesity, including alcohol consumption. Recent research suggests that excess alcohol consumption is attributable to higher BMI and increased risk of obesity (Arif & Rohre, 2005; Schröder et al., 2007).

**Pharmaceutical iatrogenesis and obesity.** Additionally, a number of medications are known to cause weight gain in adults. Common medications that lead to weight gain include antidiabetic (e.g., insulin), thiazolidinediones, sulfonylureas (SUs), tricyclic
antidepressants, selective serotonin reuptake inhibitors, lithium, antipsychotics (e.g., risperidone; clozapine; olanzapine), antihypertensives (e.g., β-adrenergic blockers), anti-seizure/anticonvulsants, cortisol and other glucocorticoids, oral contraceptives, and monoamine oxidase inhibitors (McAllister et al., 2009).

**Other causes of obesity.** Additional contributing factors suggested to affect body mass and the amount of adipose tissue include gut microbiota, specific infections (e.g., Chlamydia Pneumoniae; natural infection with the virus Ad-36), seropositivity to SMAM-1 (an avian adenovirus), epigenetics, increasing maternal age, reproductive fitness, assertive mating, disturbances in circadian rhythms (or chronodisruption), endocrine disruptors (e.g., flame retardant polybrominated diphenyl ether (PBDE); bisphenol A (BPA); diethylstilbestrol (DES)), exposure to ambient temperature below thermal neutral conditions, and intrauterine and intergenerational effects (Froy, 2007; McAllister et al., 2009; Newbold et al., 2008).

Others highlighted the influence of metabolic interactions, neuroendocrinological effects, medical conditions, problematic eating behaviors (e.g., binge eating; night eating), psychological issues (e.g., certain personality traits; low self-esteem; individual beliefs and expectations; depression; anxiety; difficulties coping with emotional stress), and social and economic factors (e.g., marital status; family situation; relation with friends; socioeconomic status) (Ball et al., 2003; Krzysztoszek et al., 2015; Pietrzykowska & Wierusz-Wysocka, 2008).
**Pathophysiology of Obesity**

Sympathetic nervous system (SNS) over activity is increasingly described in obesity pathophysiology (Smith & Minson, 2012). The mechanisms that underlie enhanced sympathetic activity in obesity remain incompletely understood; however, emerging evidence suggests that the Gly16 allele of the beta-2-adrenergic receptor gene, and certain adipokines expressed in obesity in concert with the resultant hyperinsulinemic state and elevated sympathetic outflow, may contribute to neural sympathetic overdrive (Masuo et al., 2005; Smith & Minson, 2012). Accordingly, these responses act on homeostatic systems that favor expenditure of excess energy as opposed to additional fat storage (Smith & Minson, 2012). Adipose tissue is the primary storage site for excess energy.

**Regulation of food intake and energy homeostasis.** Current evidence suggests that “obesity involves the biological defense of an elevated body fat mass” (Guyenet & Schwartz, 2012). Among the most prominent in contributing to this defect includes the interaction of brain reward and homeostatic circuits. In addition, Guyenet & Schwartz (2012) have postulated that inflammatory signaling, lipid accumulation, and/or changes in hypothalamic neurocircuits have a role in the development of obesity and perhaps provide insight into plausible biological mechanisms for the defended elevated level of fat mass.

**Central control of energy homeostasis.** Energy homeostasis is mediated mostly via complex neuronal circuits in the central nervous system (CNS). Hypothalamic and brainstem neuronal circuits play a critical role in sensing and integrating peripheral
signals to convey information about whole body nutritional and energy status (Schneeberger et al., 2013). Nuclei within the hypothalamus, which act in concert with the brainstem and communicates with the gut, make important contributions to the control of food intake and energy balance and regulation of body weight (Mayer et al., 2009; Schneeberger et al., 2013). The nuclei are the arcuate nucleus (ARC), the paraventricular nucleus (PVN), the ventromedial nucleus (VMN), the dorsomedial nucleus (DMN), and the lateral hypothalamic area (LHA). Each of the nuclei express a specific compliment of receptors, neurotransmitters, and neuropeptides (Mayer et al., 2009).

Many of the peptides expressed by orexigenic and anorexigenic neuropeptides are integral to the regulation of feeding (Mayer et al., 2009). Five hypothalamic orexigenic peptides have been identified: Neuropeptide Y (NPY), orexin A and B, agouti related peptides (AgRP), melanin concentrating hormones (MCH). Hypothalamic anorexigenic peptides include cocaine and amphetamine-regulated transcript (CART), melanocortins, glucagon-like peptides (GLP-1), neurotensin (NT), pro-opiomelanocortin (POMC) derivatives, corticotropin releasing hormone (CRH), prolactin releasing peptide (PrRP), α-melanocyte stimulating hormone (α-MSH), 5-hydroxy tryptamine (5HT), serotonin and leptin receptor (LEPR) (Crespo et al., 2014; Srivastava et al., 2007). Orexigenic peptides stimulate food intake and reward-based feeding behavior, reduce energy expenditure, and promote obesity (Cason et al., 2010; Mayer et al., 2009; Schneeberger et al., 2013; Srivastava et al., 2007). Anorexigenic peptides comparatively suppress food intake,
increase energy expenditure, and modulates energy partitioning (Mayer et al., 2009; Mercer et al., 2013; Schneeberger et al., 2013; Srivastava et al., 2007).

Four hypotheses have been proposed to explain afferent signals that modulate appetite control – namely, the lipostatic hypothesis, gut peptide hypothesis, glucostatic hypothesis, and thermostatic hypothesis (Srivastava et al., 2007). Lipostatic theory of body weight set point states that adipose tissue, which generates various signals including cytokines, hormones, and growth factors, exerts influence on food intake and energy expenditure regulation (Coelho et al., 2013). In the obese state, adipokines such as leptin, adiponectin, tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6) are dysregulated. These adipokines exert endocrine effects and work as paracrine signals upregulating other adipokines (Smith & Minson, 2012). Leptin and adiponectin are two adipokines considered to be important factors in obesity pathogenesis. Produced by white adipose, both these adipokines play important roles in lipid metabolism and insulin action. Leptin is a 16kD protein expressed mainly in adipose tissue in parallel with the amount of fat mass, although concentrations have also been shown in areas of the brain. When administered into the brain, leptin appears to suppress appetite (Smith & Minson, 2012). Adiponectin regulates in an antagonistic manner to leptin (Srivastava et al., 2007). The gut peptide hypothesis suggests that the transit of food through the gastrointestinal tract promotes satiety by stimulating secretion of gastrin-releasing peptide (GRP), glucagon, somatostatin and other appetite-suppressing gut peptides. Glucostatic hypothesis contends that decreased glucose utilization in cells increase appetite and intermittent fasting, which is related to low plasma glucose concentration and high plasma free fatty
acid concentration, reduces basal metabolic rate, leading to increased adiposity as a consequence (Coelho et al., 2013; Srivastava et al., 2007). Thermostatic hypothesis suggests that a decrease in body temperature below a given set point stimulates appetite, while an increase in body temperature above a given set point inhibits appetite (Srivastava et al., 2007).

**Obesity-Related Comorbidities and Mortality**

Obesity is associated with increased mortality and a heightened risk of comorbidities, including type 2 diabetes mellitus (T2DM), major cardiovascular diseases (CVDs), sleep-disordered breathing (SBD), nonalcoholic fatty liver disease (NAFLD), chronic kidney disease (CKD), and certain cancers (Flegal., 2013; Whitlock et al., 2009; WHO, 2011). Most studies have shown impaired health-related quality of life by higher grades of obesity with the presence of comorbidities in individuals with obesity (Oreopoulous et al., 2010; Slagter et al., 2015).

**Type 2 diabetes mellitus.** Obesity is a risk factor for T2DM, a disease characterized by insulin resistance and dysfunction of pancreatic beta β-cells. In recent years, the national prevalence of T2DM among adults ≥20 years old has increased, reaching 12.3% in 2014, which corresponds to 28.9 million (CDC, 2014). The T2DM prevalence increases substantially with increasing BMI; each 1 kg/m² BMI increase is associated with approximately 20% higher T2DM risk (Hartemink et al., 2006). At a BMI of 27.2 to 29.4 kg/m², the risk of developing T2DM increases by 100%; for a BMI >29.4 kg/m², the risk of developing T2DM increases by 200% (Hartemink et al., 2006; Meisinger et al., 2006). The risk for mortality is 1.5 times higher in adults with
diagnosed T2DM than those without diagnosed T2DM of similar age (CDC, 2014). In the context of obesity, abnormalities in insulin secretion likely contributes to destruction of pancreatic islet β-cells, and thus the proclivity to develop T2DM (Seino et al., 2011). Other possible mechanisms explaining the relationship between obesity and T2DM include oxidative stress, chronic low-grade inflammation, upregulation of gene expression of inflammatory chemokines, ectopic fat deposition, mitochondrial dysfunction, and induction of pro-inflammatory cytokines including tumor necrosis factor-alpha (TNFα), interleukin-6 (IL-6), and interleukin-1-beta (IL-1β) (Bournat & Brown, 2010; Deng & Scherer, 2010; Esser et al., 2014; Larson-Meyer et al., 2011).

Cardiovascular disease. CVD, a disorder of the heart and blood vessels, affects an estimated 85.6 million adults in the United States and approximately 43.7 million individuals older than 60 years of age (Mozaffarian et al., 2015). Furthermore, these individuals have one or more types of CVD. Hypertension (HTN), coronary artery disease (CAD), stroke, heart failure (HF), and congenital heart defects range among the most prevalent conditions. While CVD in the United States has declined in recent decades, CVD remains the leading cause or mortality, with approximately 800,000 deaths each year (Ford et al., 2007; Mozaffarian et al., 2015; NHLBI, 2013; Roger et al., 2012). Elevated BMI is associated with an increased risk of CVD (Berrington de Gonzalez et al., 2010; Czernichow et al., 2011; Poirier & Eckel, 2002; Poirier et al., 2006; Whitlock et al., 2009). Elevated BMI is also associated with an increased risk of CVD mortality, with hazard ratios (HRs) of 1.29 (95% confidence interval (CI), 1.13-1.48) at a BMI of 30.0 to 34.9 kg/m², HR of 1.87 (95% CI, 1.51-2.32) at a BMI of 35.0 to 39.0 kg/m², and HR of
2.21 (95% CI, 1.57-3.21) at a BMI of ≥40 kg/m² (Jiang et al., 2013). However, some studies have reported better prognosis among individuals with higher BMI and established CVD (Lavie et al., 2007a, 2007b, 2009a, 2009b). Potential mechanisms that underlie the link between obesity and CVD include cardiac remodeling, mitochondrial complex dysfunction, hemodynamic abnormalities, cytokine imbalance, extracellular and fibrosis alteration, neurohormonal activation, and cardiomyocyte apoptosis (Abel et al., 2008). Other possible mechanisms include reduced recovery of contractile function after either ischemia or reperfusion, alterations in myocardial substrate metabolism, decreased cardiac efficiency, and increased infarct size (Aasum et al., 2003; Boudina & Abel, 2006, 2007; Buchanan et al., 2005; Mazumder et al., 2004).

**Hypertension.** HTN is defined as elevation of arterial pressure. HTN includes patients with a mean resting systolic blood pressure greater than 140 mm Hg, diastolic blood pressure greater than 90 mm Hg, or both. HTN is a common medical problem with a prevalence approximately 29% in the United States (Joffres et al., 2013). Elevated levels of arterial blood pressure frequently coexist with obesity. Obese individuals are 3.5 times more likely of having higher prevalence of hypertension but may paradoxically have a lower risk for all-cause, CV, and non-CV mortality compared with normal-weight HTN individuals (Kotchen et al., 2008; Lavie et al., 2007b; Stamler et al., 1991; Tuomilehto, 1991; Uretsky et al., 2007). Although the pathogenesis of obesity-induced HTN is not clear at this time, several hypotheses have been described in the literature (Antic et al., 2003; Kotsis, et al., 2010; Smith & Minson, 2012). Overactive sympathetic nervous system, activation of the renin-angiotensin system, abnormal renal sodium
handling, and vascular endothelial dysfunction are proposed to be involved in the pathogenesis.

**Heart failure.** Obesity is a common contributing factor to the development of HF in the general population (He et al., 2001; Kenchaiah et al., 2002; Wilhelmsen et al., 2001). Potential mechanisms that may contribute to the development of HF in obese individuals include increased systemic inflammation, prothrombotic state, increased incidence of diastolic hypertension, and higher insulin resistance (Poirier et al., 2006). The probability of HF increases substantially with increasing BMI; each 1 kg/m² BMI increase is associated with approximately 5% higher HF risk in men and 7% in women (Kenchaiah et al., 2002). Duration of morbid obesity is also a significant predictor of HF, an association previously described (Alpert et al., 1997). Despite the adverse effects of obesity on CV function and data demonstrating a strong association of obesity with HF, many studies have suggested a favorable prognosis for obese HF patients (Curtis et al., 2005; Fonarow et al., 2007; Horwich et al., 2001; Lavie et al., 2003, 2007a).

**Coronary artery disease.** Obesity is an important risk factor of CAD as evidenced from milestone studies such as the Framingham Heart Study, Manitoba Study, and Harvard Public Health Nurses Study (Hubert et al., 1983; Manson et al., 1990; Rabkin et al., 1977). CAD is primarily characterized by the narrowing or blockage of the coronary arteries resulting from plaque buildup in the arteries. The mechanisms linking obesity to CAD are not yet certain, but potential mechanisms are abnormal hemostatic and fibrinolytic changes, oxidative stress, increased levels of proinflammatory cytokines, and increased basal sympathetic tone (Akin & Nienaber, 2015; Iacobellis & Bianco,
2011). Other possible mechanisms include excessive visceral adipose tissue, epicardial steatosis secondary to lipid metabolism abnormalities, expanded epicardial fat volume, increased mitochondrial fatty acid oxidation, depressed rates of glucose oxidation, and overexpression of factor VIII, von Willebrand factor antigen, and plasminogen activator inhibitor type I (Eckel et al., 2005; Guzzardi & Iozzo, 2011; Iacobellis & Barbaro, 2008; Iacobellis & Bianco, 2011; Iacobellis & Leonetti, 2005; Iacobellis et al., 2011; Kitagawa et al., 2015; Lopaschuk, 2014; Maghbooli & Hossein-nezhad, 2015; Mertens & Van Gaal, 2002; Osawa et al., 2014; Smith et al., 2012; Toth, 2012). The odds of CAD increase approximately 26% with each 4 kg/m$^2$ increase in BMI; the odds are even greater (52%) when factoring in genetics (Nordestgaard et al., 2012). As with HTN and HF, the paradox of better survival in individuals with a high BMI and CAD has been established (Lavie & Milani, 2003, Lavie et al., 2009; McAuley et al., 2007; Romero-Corral et al., 2006).

**Airway.** SBD is characterized by intermittent, cyclical cessations in breathing rhythm (apneas) or temporary reductions in breath amplitude (hypopneas) that disrupt normal sleep (Dempsey et al., 2010). It is a spectrum of breathing anomalies ranging from snoring to upper airway resistance syndrome (UARS; repeated arousals and increased upper airway resistance) to obstructive sleep apnea (OSA; characterized by episodic partial or complete upper airway obstruction during sleep), or in some cases, obesity hypoventilation syndrome (OHS; defined by the coexistence of obesity and arterial hypercapnia during wakefulness) (BaHammam, 2010; Chan et al., 2010; Dempsey et al., 2010; Gunhan, 2013; Mbata & Chukwuka, 2012; Mokhlesi, 2010;
Nowbar et al., 2004). SBD is highly prevalent among hospitalized patients with morbid obesity; with OSA found in 40% to 75%, the OHS in 10% to 31% (Dixon et al., 2003; Lopez et al., 2008; Mokhlesi, 2010; Mokhlesi et al., 2007; Musso et al., 2013; Nowbar et al., 2004; Palla et al., 2009). The incidence of OSA and OHS increase significantly as BMI increases (Nowbar et al., 2004; Lopez et al., 2007). Obese patients with OHS are generally considered to be more severely affected and thus tend to carry higher morbidity and mortality than simple obesity or OSA (Castro-Añón et al., 2010; Nowbar et al., 2004; Piper & Grunstein, 2011). Results from Castro-Añón et al. (2010) have shown a two-fold increased risk of death in OHS patients. Several mechanisms have been postulated linking obesity with SBD, including anatomical imbalance of forces acting on the pharyngeal airway during inspiration, reduced lung volumes and longitudinal pharyngeal wall tension secondary to greater central fat distribution, biochemical disturbance associated with hypoventilation, functional impairment in upper airway muscles, and craniofacial abnormalities (Carrera et al., 2004; Isono, 2011; McNicholas, 2000; Piper & Grunstein, 2011; Sands et al., 2014; Watanabe et al., 2002).

Liver. Obesity is an important risk factor for NAFLD, a condition hallmarked by triglyceride accumulation in the hepatocytes in the absence of alcohol consumption (Yuki & Cohen, 2013). NAFLD encompasses a spectrum of disease from simple steatosis to nonalcoholic steatohepatitis (NASH), which could progress to cirrhosis or hepatocellular carcinoma over time, and is associated with increased mortality (Argo et al., 2009; Cohen et al., 2011; Ekstedt et al., 2006; Sheth et al., 1997; Starley et al., 2010). The prevalence of NAFLD is 20% to 30% of the general population in Western countries and 63% to
95% in morbid obese individuals, to almost 100% of morbid obese individuals with T2DM (Abrams et al., 2004; Bellentani & Marino, 2009; Beymer et al., 2003; Boza et al., 2005; Browning et al., 2004; Colicchio et al., 2005; Cortez-Pinto et al., 2006; Dolce et al., 2009; Gholam et al., 2007; Harnois et al., 2006; Liew et al., 2008; Machado et al., 2006; Ong et al., 2005; Ruhl & Everhart, 2004; Spaulding et al., 2003). Obesity-associated NAFLD might be attributed to mechanisms such as chronic inflammation, increased hepatic free fatty acid supply, ectopic lipid accumulation, oxidative stress and mitochondrial dysfunction, altered gut microbiota, and insulin resistance (Byrne & Targher, 2014; Donnelly et al., 2005; Dowman et al., 2010; Feldstein et al., 2004). Despite having a higher prevalence of NAFLD in obesity, recent data have shown that individuals with NAFLD and higher BMIs have lower mortality rates than those who are lean (De la Cruz et al., 2014).

Kidney. Obesity is an independent risk factor of CKD. CKD is “associated with age-related renal function decline accelerated in hypertension, diabetes, and obesity and primary renal disorders” (Hill et al., 2016). Prevalence of CKD has been increasing in parallel with the prevalence of obesity (Hall et al., 2002, 2004). The prevalence of CKD in the United States has risen from 12% in 1988 to 1994 to 14% in 1994 to 2004, but has remained relatively stable since (The National Institute of Diabetes and Digestive and Kidney Diseases, 2016). Data demonstrate that elevated BMI and waist circumference may increase the incidence of CKD (Burton et al., 2012; Gelber et al., 2005; Gomez et al., 2006). Individuals with CKD have a 59% higher mortality rate than that of non-CKD individuals (USRDS, 2012). Mechanisms whereby obesity directly impacts kidney
disease include increased glomerular capillary wall tension, hyperfiltration, and podocyte stress (Wickman & Kramer, 2013).

**Cancer.** Obesity is associated with increased risk of cancer incidence and mortality. The chronic increase in obesity prevalence in the United States presumably contributes to 20% of cancer deaths (Colditz et al., 2012). The mechanisms underlying obesity-related carcinogenesis remain poorly understood; however, insulin resistance, insulin-like growth factor (IGF-1), adipokines (e.g., leptin; adiponectin; visfatin), inflammatory cytokines, insulin/IGF-1, and phosphatidylinosotide 3-kinase-AKT-mammalian target of rapamycin (PI3K-Akt-mTOR) pathway genes, and sex hormones (e.g., androgens; estrogen; progesterone) are factors that might explain this association (Berger, 2014; Chen et al., 2009; Dann et al., 2007; Gunter et al., 2009; Hursting et al., 2008; Jiang et al., 2008; Ma et al., 2004, 2008; Moore et al., 2008a, 2008b; Renehan et al., 2008; Rinaldi et al., 2010; Roberts et al., 2010; Sundaram et al., 2013).

**Management and Treatment of Morbid Obesity**

Management of morbid obesity through lifestyle, pharmacological, or surgical interventions has been described in the literature (Behary & Kumbhari, 2015; Gloy et al., 2013; Li et al., 2005; Wadden et al., 2005). Diet and exercise themed management requires significant discipline and many morbidly obese individuals may find it difficult to instigate and maintain a consistent regimen (Espeland, 2007; Glandt & Raz, 2011; Gloy et al., 2013; Ryan et al., 2010; Sjöström et al., 2004; Wadden et al., 2012). Pharmacologic therapy offers a possible adjunct when weight loss is not achieved through diet and exercise alone; however, its impact is modest and is limited by side
effects, contraindications, and compliance rates (Glandt & Raz, 2011; Kaukua et al., 2003; Li et al., 2005; Moyers, 2005; Wadden et al., 2005). Surgical intervention traditionally is recommended only as medically necessary and it acts as an ancillary measure when patients whose body mass index (BMI) is ≥40 kg/m² or those with BMI ≥35 kg/m² with obesity-related comorbidities fail diet, exercise, and drug therapy (Mechanick et al., 2008; 2013). Bariatric surgery, a surgical procedure of the stomach or intestines, provides a durable and effective method of treating morbid obesity and related diseases (Behary & Kumbhari, 2015; Carlin et al., 2013; Courcoulas et al., 2014b; Gloy et al., 2013; Maggard et al., 2005; Mechanick et al., 2013; Neff et al., 2013; Nguyen et al., 2011; Padwal et al., 2011; Schauer et al., 2003; Serrano et al., 2015; Sjöström et al., 2004, 2007).

**Bariatric Surgery**

The following section discusses the trends in bariatric surgical procedures at the global and regional scale, and common bariatric surgical procedures and surgical techniques. It also examines postoperative risk and complications, alterations in physiological metabolic processes, and clinical outcomes.

**Trends in Bariatric Surgical Procedures**

For nearly two decades, bariatric surgery has established itself as a safe, durable and effective treatment for patients with severe and morbid obesity (BMI ≥40 kg/m², or ≥35 kg/m² with obesity-related health conditions) and its associated comorbidities (Serrano et al., 2015). In 1998, Nicola Scopinaro, MD published a survey summarizing the status of metabolic/bariatric procedures worldwide. Scopinaro is a Professor of
Surgery (Honorary President of International Federation for the Surgery of Obesity (IFSO) and Metabolic Diseases) at the University of Genoa Medical School, Genoa, Italy and President of the Italian Society of Obesity Surgery.

The increase in IFSO nations (or national groups) in 2013 represented a staggering change from 2003. There are currently 58 official member societies of IFSO and four regional chapters: European, North American, Latin American, and Asian Pacific (IFSO, 2014b, 2014c). The IFSO was established in 1995 by the world’s foremost experts in metabolic/bariatric surgery, with the intent “to bring together surgeons and allied health professionals . . . involved in the treatment of morbidly obese patients” (IFSO, 2014a). The goals of the organization are twofold: to optimize the surgical treatment of severely obese patients, and to support its member in various aspects relative to their health care profession (IFSO, 2014a).

Since 1998, follow-up reports on members of bariatric societies belonging to IFSO have been gathered by Buchwald & Williams (2004), Buchwald & Oien (2009, 2013), and Angrisani et al. (2015) to conduct outcome evaluation and trend analyses, and submitted to the IFSO. The follow-up report measured total population per country, global total bariatric procedures performed yearly, global total number of bariatric/metabolic surgeons, types of procedures performed per country/region, choice of procedures, and global and regional trends. The total number of bariatric centers and their number of cases per year were also measured. As with the preliminary report, the 2003-2013 follow-ups were prepared by collecting and analyzing available data from national bariatric surgery registries from all IFSO member countries and previously
published data. The subsequent report, *Bariatric Surgery Worldwide 2013*, surveyed nations or national groupings of the IFSO to provide statistics about the number and type of bariatric procedures performed over a one-year period. The report also provides better understanding of the changes in the surgical community which affect current and future bariatric surgery trends (Angrisani et al., 2015; Buchwald & Oien, 2009, 2013; Buchwald & Williams, 2004).

**Global trend.** Global trend in bariatric surgery utilization in different countries was 468,609 in 2013, driven by a twofold increase in obesity prevalence. Majority (95.7%) of those procedures were carried out laparoscopically (Angrisani et al., 2015). Between 1998 and 2013, the total number of procedures performed rose substantially in 15 years. From 1998 to 2003, the number of bariatric surgeries increased markedly and continued to rise from 2003 to 2008. Although the total bariatric surgeries (Roux-en-Y gastric bypass (RYGB), laparoscopic sleeve gastrectomy (LSG), laparoscopic adjustable gastric banding (LAGB), and biliopancreatic diversion/duodenal switch (BPD/DS)) performed had a modest decrease in trend from 2008 to 2011, the number of weight loss surgeries performed had a marked increase (+38%) in trend between years 2011 and 2013 (Angrisani et al., 2015). Figure 1 shows the increase between 1998 and 2013.
Figure 1. Global Trend in Bariatric Surgeries Performed, 1998-2013.

The countries that performed the most bariatric procedures in 2013 include: (1) United States/Canada: 154,276; (2) Brazil: 86,840; (3) France: 37,300; (4) Argentina: 30,378; (5) Saudi Arabia: 13,194; (6) Belgium: 11,500; (7) Israel: 11,452; (8) Australia-New Zealand: 10,467; (8) India: 10,002.

RYGB accounts for a significant percentage of worldwide weight loss procedures compared with the other types of procedures as reported by the four IFSO regional chapters. In 2003, global data estimated that 65.1% of the total procedures performed were RYGB. The top three bariatric operations, following the RYGB, together accounted for 34.6% of procedures performed. More than 95,000 (n=95,257) RYGB operations were performed that year, which made it the most performed weight loss procedure worldwide. In 2003, the makeup of bariatric surgery worldwide consisted
primarily of laparoscopic (62.8%) and open (37.1%) procedures. Top procedures frequently performed were laparoscopic gastric bypass (25.6%), LAGB (24.1%), open gastric bypass (23.0%), laparoscopic long-limb gastric bypass (8.9%), open long-limb gastric bypass (7.4%), and open vertical banded gastroplasty (4.2%) (Buchwald & Williams, 2004). No SG’s were performed in 2003, according to published data. By 2011, the makeup of bariatric surgery worldwide consisted primarily of RYGB (46.6%), LSG (27.8%), AGB (17.8%), BPD/DS (2.2%), mini gastric bypass (1.5%), vertical banded gastroplasty (0.7%), electrical pacers (.01%), and other/revisions (3.4%) (Buchwald & Oien, 2013).

As detailed in Figure 3, there was a decrease in the use of RYGB over the 10-year time span. The percentage of procedures fell from 65.1 to 49% in 2008 and then fell to 45% by 2013. While utilization growth for RYGB had decelerated, this did not affect it being the premier choice for treatment of obesity (Figure 2). From 2008 to 2011 to 2013, the total number of procedures performed were 168,597, 156,760, and 209,352, respectively (Angrisani, et al., 2015).

RYGB represented 45% of total 2013 bariatric surgeries performed globally. The distribution of the remaining surgeries – 37% LSG, 10% AGB, and 1.5% BPD/DS – collectively represented approximately half (48.5%) of total bariatric surgeries performed in 2013. Other procedures never exceeded 2.5%. The top two procedures, RYGB and LSG, accounted for 82% of overall procedures performed throughout the world (Angrisani et al., 2015).
In 2003, the trend for LSG was flat (0%); neither nations nor national groups reported LSG being performed in their country during this time. The global trend for LSG grew 5.3% in 2008, with decreased utilization of LAGB the primary driver. From 2008 to 2013, the utilization trend for LSG was positive (+31.7%). Starting in 2008, the total number of LSG procedures performed was 18,098. By 2011, total LSG procedures performed was 94,689, up 22.5%. SG rose to 172,320 in 2013 (Angrisani et al., 2015).

LAGB worldwide peaked in 2008 (42.3%). The 2008 global trend in the number of LAGB procedures was 145,563, up 17.9% from 35,712 in 2003. In 2011, LAGB decreased 24.5%, to 60,677, and then fell to 46,310, reflecting a 7.8% decrease between 2011 and 2013 (Figures 2 and 3). Utilization growth for BPD/DS has decelerated as well (Angrisani et al., 2015). The leading bariatric surgical procedures performed worldwide in 2013 were: (1) RYGB: 209,352; (2) LSG: 172,320; (3) LAGB: 46,310; (4) BPD/DS: 7,169.

**Regional trend: United States/Canada.** The introduction of the jejunoileal bypass, the first effective surgery for morbid obesity, ushered in the era of modern bariatric surgery (Baker, 2011). RYGB remains the “gold standard” technique in weight loss surgery in North America. From its infancy in 1954 till today, original procedures of bariatric surgery have undergone several variations and refinements (Baker, 2011). Since the American Bariatric Surgeon Alan Wittgrove performed the first laparoscopic gastric bypass in 1993, surgeons have adopted minimally invasive surgical (MIS) techniques, primarily laparoscopy, to perform several procedures that were previously performed using the traditional open approach. Laparoscopy is most widely accepted for bariatric
procedures unless contraindicated. Surgeons use laparoscopy in >90% of bariatric cases (Nguyen et al., 2011; Padwal et al., 2011). Improvements in intraoperative techniques (i.e., the use of MIS techniques as opposed to traditional open techniques) and pre- and perioperative care of high risk surgical patients have resulted in shorter lengths of hospital stays, decreased postoperative pain, quicker recovery, and fewer postoperative complications and adverse events. Use of bariatric procedures in the United States/Canada have increased but have since plateaued in recent years (Kohn et al., 2009; Nguyen et al., 2011). Changes over time in the utilization of available procedures reflect emerging evidence comparing clinical effectiveness, safety, and cost-effectiveness (Carlin et al., 2013; Padwal et al., 2011).

RYGB, which held the number-one spot in total procedures performed for eight years, represents the most performed bariatric procedure at medical centers in the United States/Canada. Compared to 2003 global data, the RYGB did not lead United States/Canada utilization of bariatric surgery. At 11.1%, RYGB ranked second to AGB, which accounted for 63.7% of total procedures that year (Figure 5). However, RYGB far exceeded the other surgeries in total number of procedures performed during in 2003 (Figure 4). After five years of increase, trend in the utilization of RYGB performed at medical centers decreased substantially in 2011, to 47,791 (down from 112,200 in 2008). During the same time period, use of RYGB plateaued (-3%) and finally decreased in 2013 (-11.7%) (Figure 5) (Angrisani et al., 2015).

Over the last decade, one main pattern in bariatric procedures has emerged: growth in the use of LSG has accelerated (Figure 4). From 0% in 2003, the overall trend
rose to 37% in 2013. During the same time period, total LSG procedures performed surpassed that of RYGB (67,021 vs. 54,420, respectively). Comparable to global trends in number of procedures, LAGB rose from 9,270 to 96,000 in 2008 then fell to 27,630 in 2011 and as low as 15,523 in 2013. Concurrently, BPD/DS, as depicted by Figure 5, never rose to over 10% prevalence in the United States/Canada Region (Angrisani et al., 2015). The leading bariatric surgical procedures performed in the United States/Canada in 2013 were: (1) LSG: 67,021; (2) RYGB: 54,420; (3) LAGB: 15,523; (4) BPD/DS: 1,520.


![Figure 2. Global Trend in Bariatric Surgery, 2003-2013.](image-url)
Figure 3. Global Trends in Percentage of Bariatric Procedures, 2003-2013.

Figure 4. Regional Trend in Bariatric Surgery, 2003-2013 for United States/Canada.
Bariatric Surgical Procedures

Surgical techniques of bariatric procedures are classified as restrictive and/or malabsorptive based on the presumed mechanism of weight loss (Arterburn & Courcoulas, 2014; Buchwald & Oien, 2013; Mingrone et al., 2012; Schauer et al., 2012; Sugerman, 2001). Restrictive procedures involve constructing a small gastric pouch limited to the upper portion of the stomach to restrict food intake and delay gastric emptying in order to induce early satiety. “Malabsorptive techniques divert biliopancreatic secretions, limiting the absorption of nutrients in the intestine” (Anderson et al., 2013). Combined procedures incorporate both restrictive and malabsorptive elements.
Laparoscopic versus open bariatric surgical procedures. Minimally invasive bariatric surgery has become a widely accepted procedure. Some studies have demonstrated that laparoscopic bariatric surgery yields lower absolute mortality risk, earlier decline in postoperative morbidity, fewer immediate and late postoperative complications, faster recovery, less postoperative pain, and return of patients’ functionalities when compared to open surgery (Buchwald et al., 2007; Maggard et al., 2005; Nguyen, 2004; Podnos et al., 2003; Reoch et al., 2011; Salem et al., 2008; Tiwari et al., 2011). The most common surgical procedures are the laparoscopic Roux-en-Y gastric bypass (LRYGB), laparoscopic sleeve gastrectomy (LSG), laparoscopic adjustable gastric banding (LAGB), and biliopancreatic diversion, with or without duodenal switch (BPD and BPD/DS).

Laparoscopic Roux-en-Y gastric bypass. Roux-en-Y gastric bypass (RYGB) is currently considered as the “gold standard” method of weight loss and remains the most common bariatric/metabolic operation performed in the United States and Canada (ASMBS, 2015). This technique, which has a dual restrictive and malabsorptive mode of action, has undergone many developments of technological evolution, particularly the laparoscopic approach. The history of bypass procedures began almost 40 years ago, with the first report of gastric bypass made in 1976 by Mason and Ito (1976). In 1977, Griffen Jr et al. introduced for the first time the term Roux-en-Y. The same year, Alden (1977) introduced the use of surgical staplers for gastric partition. In 1994, Wittgrove et al. were the first to describe laparoscopic Roux-en-Y gastric bypass (LRYGB). The potential advantages of LRYGB are the established effectiveness for sustained weight
loss, reduction in comorbidities, minimal invasivity, reduction of postoperative complications and pain, lowered risk for long-term nutritional sequelae, and lowering in circulating ghrelin levels blunting the appetite drive (Angrisani et al., 2007; Biertho et al., 2003; Boza et al., 2010; Carlin et al., 2013; Chang et al., 2014; Christou & Efthimiou, 2009; Fakhro, 2008; Jan et al., 2007; Kelly et al., 2009; Lim et al., 2014; Meek et al., 2016; Wittgrove & Clark, 2000; Wong et al., 2009). The potential disadvantages of LRYGB include the irreversibility, longer learning curve, modification on gut orientation, risk of postoperative malnutrition (due to poor compliance with multivitamin/mineral regimen or poor diet), and anastomotic complications (Decker et al., 2007).

The LRYGB is an irreversible procedure that consists in (1) transection of the fundus (upper portion of the stomach), forming a 15 to 30 mL proximal gastric pouch just distal to the gastroesophageal junction, (2) division of the jejunum at a point 30 to 75 cm from the ligament of Treitz, and (3) gastrojejunal anastomosis between gastric pouch and the Roux-en-Y proximal jejunal segment accompanied by a bypass of the remaining stomach, duodenum, and proximal jejunum, and jejunojejunal anastomosis of the excluded biliary limb and gastric remnant to the bowel some 75 to 150 cm from the gastrojejunostomy (Mechanick et al., 2013; Neff et al., 2013).

LRYGB has proven to be successful in achieving significant, sustainable weight loss over time in the morbidly obese population (BMI 40.0 kg/m² – 50.0 kg/m²). Dogan et al. (2015) in a multicenter matched cohort study retrospectively analyzed 735 morbidly obese patients who underwent either LRYGB, LAGB or LSG. Preoperative BMI was
significantly higher in the LRYGB group compared to the LAGB group 47.2 kg/m$^2$ versus 44.8 kg/m$^2$, $p<0.001$), while preoperative BMI for LRYGB was higher compared to LSG (45.8 kg/m$^2$, $p=0.008$), but no significance was reached. All three procedures achieved reduction in body weight and BMI during the five-year postoperative follow-up period. Percentage of excess weight loss (%EWL) was found to be significantly greater in the LRYGB group compared to LAGB during the five postoperative years. A statistically significant higher BMI was found in the LAGB group compared to the LRYGB ($p<0.001$) throughout the duration of the follow-up time except at five years postoperatively ($p=0.056$). Among LRYGB and LSG, both procedures achieved marked reductions in body weight and BMI. Patients with LSG lost slightly more weight at year one, but this was not statistically significant. BMI values were similar at year one, with no significant differences between procedures. BMI and weight reduction were significant at two, three, four, and five years after LRYGB and LSG. At year five BMI was reduced 32.9±5.9 and 32.6±5.5 after LRYGB and LSG respectively. Similarly, statistical significance was recorded in %EWL at two, three, four, and five years between LRYGB and LSG groups. LRYGB and LSG achieved comparable weight losses after three and four years. Concerning LRYGB, EWL was maintained $\geq50\%$ throughout the five years of follow-up; the maximum %EWL occurred one and two years postoperatively with a mean %EWL of 70.8% and 72.3%, respectively. Overall, several prospective cohort studies investigating LRYGB suggest similar results with %EWL ranging from 65% to 100% (one year), 61% to 103% (two years), 66% to 92% (three years), 63% to 91% (four years), and 59% to 93% (five years) (Angrisani et al., 2007;
Micronutrient and protein deficiencies following gastric bypass are frequent despite routine supplementation (Aron-Wisnewsky et al., 2016; Bernert et al., 2007; Gasteyger et al., 2008; Shah et al., 2011; Verger et al., 2016). Severe malnutrition is rare but deficiencies of iron, vitamin B12, folate, calcium, and vitamin D (25-OH vitamin D and PTH) are common. Postoperative deficiencies of copper and vitamins B1 (thiamin) A, K, E have also been reported, although less frequently, after LRYGB surgery (Bernert et al., 2007; Griffith et al., 2009; Haddad et al., 2008; Shah et al., 2011). Shortage of the aforementioned micronutrients largely occur as a result of exclusion of the duodenum and proximal jejunum, physiologic or pathologic losses, inadequate dietary intake due to intolerance, decreased gastric acidity, poor secretion of intrinsic factor (IF) (particularly for vitamin B12 absorption), and fat malabsorption related to delayed mixing of dietary fat with pancreatic enzymes and bile salts (Aron-Wisnewsky et al., 2016; Decker et al., 2007; Obinwanne et al., 2014; Shah et al., 2011). Additional factors that may further exacerbate nutritional deficiencies include nonadherence to supplementation regimens, certain medications, protracted vomiting, excessive alcohol consumption, and preexisting nutritional deficits. Clinically, there have been case reports of post-LRYGB anemias associated with decreased erythropoiesis or iron and copper deficiencies, LRYGB-related calcium and vitamin D deficiency and associated metabolic bone disease or secondary hyperparathyroidism, post-LRYGB thiamin deficiency-associated Wernicke’s
encephalopathy, and myelodysplasia or myelopathy as a result of copper deficiencies (Chen et al., 2013; Huff et al, 2007; Juhasz-Pocsine et al., 2007; Kim & Brethauer, 2014; Kumar et al., 2003, 2004; Shah et al., 2011).

Various short-term and long-term hepatobiliary, luminal, and functional complications with varying degrees of morbidity and mortality risk, are reported after LRYGB (Decker et al., 2007). The reported incidence of complication rates after LRYGB varies widely in the literature: between 4.6% to 32% (Boza et al., 2010; Chang et al., 2014; Christou & Efthimiou, 2009; Jan et al., 2007). Most concerns perioperative complications such as anastomotic or staple line leaks, gastrointestinal hemorrhage, small bowel obstruction (due to adhesions), dumping syndrome, and wound infection (Decker et al., 2007; Ramadan et al., 2016; Siddique & Feuerstein, 2014). Late complications include marginal ulceration, anastomotic stricture, gastrogastric fistula, symptomatic cholelithiasis, intussusception, bile reflux, gastroesophageal reflux disease (GERD), and dumping syndrome (Coupaye et al., 2015; Decker et al., 2007; Ramadan et al., 2016; Siddique & Feuerstein, 2014). Venous thromboembolism (VTE) is an infrequent event but potentially fatal complication of gastric bypass.

**Laparoscopic sleeve gastrectomy.** The novel LSG is putatively a purely restrictive operation designed to reduce total gastric reservoir volume/capacity thereby limiting caloric intake by promoting early satiety (Gletsu-Miller & Wright, 2013; Karmali et al., 2010). Open SG was first described in 1988 by Douglas Hess, MD and again in 1990 by Picard Marceau, MD as a first step to the duodenal switch procedure and as an extension of the Magenstrasse and Mill gastroplasty (Hess & Hess, 1998;
Jossart & Anthrone, 2010; Marceau et al., 1998). In 1998, the first experience of open technique of SG was performed (Hess & Hess, 1998). In 1999, the first laparoscopic duodenal switch (DS) with SG was performed in a porcine model and a feasibility study between the latter and open approach took place (de Csepel et al., 2001). One year later, in the clinical setting, the first laparoscopic SG was performed as part of a DS (Gagner & Rogula, 2003). The procedure was found as a safe and feasible salvage procedure for inadequate weight loss after BPD/DS (Gagner & Rogula, 2003). Not long after was LSG presented to provide a feasible, effective and alternative method of treatment in high-risk obese patients after LRYGB (Regan et al., 2003).

LSG has grown in popularity in recent years worldwide because of its perceived technical simplicity, marked weight loss, low morbidity and mortality, reduction and/or improvement of obesity-related comorbidities, absence of malabsorption, preservation of the pylorus, maintenance of normal gastrointestinal continuity, avoidance of foreign material, reduction of circulating ghrelin, and ability to covert to other procedures (Ariyasu et al., 2001; Brethauer et al., 2009; Cummings, 2006; Gumbs et al., 2007; Langer et al., 2005; Lee et al., 2007). It is now a stand-alone bariatric procedure in the super-obese patient or the high-risk patient with multiple comorbidities (Franco et al., 2011; Gagner et al., 2008; Himpens et al., 2010; Lee et al., 2007; Weiner et al., 2007). The potential concerns with LSG relate to its irreversibility, increased postoperative risk, and unproven durability (Brethauer et al., 2009).

Lateral-to-medial approach and reverse medial-to-lateral approach are the common most techniques used for LSG. The lateral-to-medial approach involves initial
entry into the peritoneal cavity, CO₂ insufflation to establish pneumoperitoneum, port placement, downward dissection of the greater curvature approximately 2 to 10 cm proximal to the pylorus, mobilization of the greater curvature toward the angle of His, subsequent creation of gastric reservoir of <150 mL, dissection of the dorsal gastro-pancreatic adhesions in the cranial direction, placement of a 32-60 French bougie along the lesser curvature of the stomach, staple transection, and the final removal of gastric specimen (Biter et al., 2015; Chambers et al., 2012; Gadiot et al., 2011; Karmali et al., 2010). The medial approach comparatively involves transversal of the lesser omentum (i.e., entering the lesser sac) first, followed by, dissection of the small gastric vessels, bougie insertion, firing of a linear stapler along the length of the bougie until the angle of His is reached, partial mobilization of the greater curve inside the epiploic arcade close to the gastric wall, and finally full mobilization of the greater curve beginning 2 to 10 cm proximal to the pylorus and extending to the angle of His leaving a gastric pouch of <150 mL capacity (Biter et al., 2015; Karmali et al., 2010).

Several prospective and retrospectives series suggest safe and effective weight loss in the first postoperative years with LSG as a stand-alone procedure. In a large series of 1,000 consecutive LSG cases, Boza et al. (2012) in a study of 773 patients reported a %EWL of 87%, 84%, and 85% at year one, two years, and three years of follow-up. More recently, Dogan et al. (2015) demonstrated an EWL of 76.5±23.4% after one year, 75.4±24.7% after two years, and 69.7±25.1% after three years. Similarly, Gibson et al. (2015) in a retrospective series of 500 consecutive LSG patients showed an EWL of 76% at one year, 71% at two years, and 73% maintained at three years follow-
Alexandrou et al. (2015), Brethauer et al. (2009), Fischer et al. (2012) and Shi et al. (2010) performed a retrospective review of five-year data after LSG. After LSG, these studies reported gradual declines in weight loss, varying from 80% to 53% EWL after one to five years of follow-up (Alexandrou et al., 2015; Brethauer et al., 2009; Fischer et al., 2012; Shi et al., 2010). Within a mid-term follow-up after LSG, a marked decline %EWL is often seen after the third postoperative year. Although the general trend is that patients experience a gradual decline in percentage of weight change, short- and mid-term trajectories of EWL remain above 50%. Data from the Third International Summit for Sleeve Gastrectomy confirm these outcomes (Deitel et al., 2010). Few data have been published so far on long-term outcomes for LSG (Diamantis et al., 2014; Eid et al., 2012; Felsenreich et al., 2016; Sarela et al., 2012). Based on these data, the risk of weight regain and intractable reflux within follow-up of more than 10 years are high requiring possible reoperation or laparoscopic conversion from gastric sleeve to RYGB (Felsenreich et al., 2016).

While long-term data on micronutrient status following LSG remain limited, nutritional deficits after the procedure have been demonstrated in studies with five years of follow-up (Aarts et al., 2011; Ben-Porat et al., 2015; Capoccia et al., 2012; Coupaye et al., 2014; Damms-Machado et al., 2012; Gehrer et al., 2010; Hakeem et al., 2009; Himpons et al., 2006; Kwon et al., 2014; Moizé et al., 2013; Pech et al., 2012; Saif et al., 2012; van Rutte et al., 2014; Vargas-Ruiz et al., 2008; Verger et al., 2016). Following LSG, inadequacies of iron, folate, and vitamins B1, B6, B12, and D are prevalent. When abstracting morbid obese individuals who present with deficits in the corresponding
micronutrients presurgery, LSG has a modest effect on micronutrient status within the first postoperative year (Damms-Machado et al., 2012). Reports of micronutrient status after LSG suggested that newly developed postoperative deficiencies can be confined to iron, folate, and vitamin B12, although they occur less frequently than alternative, more aggressive procedures – notably LRYGB, BPD, and BPD/DS (Aarts et al., 2011; Capoccia et al., 2012; Damms-Machado et al., 2012; Gehrer et al., 2010; Himpens et al., 2006; Hakeam et al., 2009; Kehagias et al., 2011). Potential mechanisms of the corresponding micronutrient deficiencies include duodenal-jejunal passage reconstruction, fundus resection, lack in secreted hydrochloric acid, reduced production of IF, accelerated gastric emptying, and inadequate dietary intake (Aills et al., 2008; Craggs-Dino, 2014; Damms-Machado et al., 2015; Melissas et al., 2008; Verger et al., 2016). Despite routine supplementation, patients may be at risk of post-LSG anemias (microcytic and pernicious) associated with iron, B12, and folate deficiencies, LSG-related vitamin D deficiency and associated metabolic bone disease or secondary hyperparathyroidism, and post-LSG thiamin deficiency-associated Wernicke-Korsakoff syndrome (Aarts et al., 2011; Capoccia et al., 2012; Gehrer et al., 2010; Hakeam et al., 2009; Jeong et al., 2011; Makarewicz et al., 2007; Scarano et al., 2012).

**Laparoscopic adjustable gastric band.** Like LSG, LAGB is a purely restrictive procedure and remains popular among bariatric surgeons in Australia, Europe, and South America due in part to “its adjustability, reversibility, and preservation of gastrointestinal tract continuity” (Manatakis et al., 2014). The use of LAGB is generally performed less often in the United States. The procedure consists in the placement of a synthetic band
with an expandable silastic balloon distal to the gastroesophageal junction, creating a 20 to 30 mL gastric pouch at the cardia (Neff et al., 2013; Sawaya et al., 2012). The restrictive technique of LAGB reduces gastric volume in the proximal portion of the stomach inducing delay in gastric emptying (Sawaya et al., 2012). LAGB although associated to a lower morbidity ratio and peri- and postoperative complications demonstrate high reoperation rate (Manatakis et al., 2014). The frequency of device-related complications in the morbidly obese as reported by Snyder et al. (2010) can reach up to 48%. Frequently reported early (within one-month after operation) complications after LAGB include band obstruction, wound infection, gastric perforation, and bleeding (Manatakis et al., 2014). In addition to the early postoperative complications of this surgery, patients undergoing LAGB are prone to band slippage/migration, pouch enlargement, esophageal dilation, gastric erosion, gastric necrosis, port-site infection, port breakage, and tubing complications (Eid et al., 2011; Manatakis et al., 2014; Zinzindohoue et al., 2003). The incidence of the aforementioned late postoperative complications has led to inadequate weight loss, secondary weight regain, and revision or conversion to another bariatric operation (i.e., LRYGB, LSG, or BPD) (Manatakis et al., 2014).

Modest weight loss associated with significant improvements in medical conditions in LAGB have been demonstrated in the morbidly obese population (BMI >40 kg/m²). Tice et al.’s (2008) systematic review which included 14 comparative studies for a total of 6,599 patients compared two different bariatric surgical procedures, LAGB and LRYGB. This review suggests that LAGB although associated with lower complication
rates and very low mortality demonstrate less efficiency in regard to excess body weight loss (EBWL) and resolution of comorbidities than when compared to LRYGB. One year after surgery mean percentage of EWL was found to be 37.8% following LAGB compared to 62.8% following LRYGB. Comparing the LAGB versus the LRYGB group across the 12 studies reporting weight loss outcomes after one year of follow-up, the absolute EWL corresponded to a large, clinically significant difference of 25%. “In several of the studies, these differences tended to narrow over time, although in others, the differences remained stable” (Tice et al., 2008). One randomized trial had demonstrated EBWL stabilizing over a five-year time frame. Similar results were observed for absolute differences in the resolution of comorbidities (Cottam et al., 2006; Weber et al., 2004). Greater differences were observed by Bowne et al. (2006) in their prospective analysis of patients with BMI >50 kg/m². Contrarily, Galvani et al. (2006) and Kim et al. (2006) compared weight loss and early outcome comorbidity resolution after one and two years in morbid (BMI >40 kg/m²), superobese (BMI >50 kg/m²), and super-superobese (BMI >60 kg/m²) patients who underwent LAGB versus LRYGB and reported resolution or improvement of comorbidities to be similar between the two groups, with better weight loss outcomes in the LRYGB group.

Zinzindohoue (2013) in a prospective study of 500 morbidly obese patients with mean initial BMI of 44.3 kg/m² showed an EWL of 42.8% after one year, 52% after two years, and 54.8% after three years of follow-up, with resolution of comorbidities of 24% or more. Closing results showed that this operation, after a 48-month period postoperatively, was comparable to the stapling technique in terms of weight loss in the
morbid obese and super obese patients while presenting acceptable operative risk and lower risk for complications (Zinzindohoue et al., 2013). Concordantly, Franco et al.’s (2011) systematic review found a EWL ranging from 45% to 48% during at least a four-year follow-up. Patients who undergo LAGB surgery usually lose about 40% to 60% of their excess body weight in the first year after surgery (K. Knopp, personal communication, September 11, 2015).

LAGB displays a lower prevalence of micronutrient deficiencies compared to other bariatric surgeries, due to preservation of the natural anatomy of the gastrointestinal tract (neither end-to-end anastomoses nor extensive dissections of the small bowel are performed). As LAGB “provides a profound mechanical effect to restrict food intake,” (Pedersen, 2013) it would be expected that this procedure would compromise nutritional status. Accordingly, Snyder et al. (2010) demonstrated that LAGB placement was associated with a decline in iron, vitamin B12, folate, thiamin, and vitamin D.

**Biliopancreatic diversion and biliopancreatic diversion-duodenal switch.**

BPD was described in 1979 by Scopinaro et al. (1979) as an alternative procedure to Jejuno-Ileal Bypass to patients with morbid obesity. In the BPD, a partial distal gastrectomy is performed, in which the distal end of the duodenum (duodenal stump) is closed and a gastric pouch (volume of gastric remnant 200 to 500 mL) is created (Mechanick et al., 2013; Neff et al., 2013). The initial division of the small bowel (small intestine) is a distal transaction between the ligament of Treitz and the ileocecal valve some 250 cm from the disconnected Roux limb (Neff et al., 2013). The small bowel is bypassed and the biliopancreatic limb (duodenum) and alimentary limb (gastric remnant)
are redirected to the ileum 50 cm from the ileocecal valve via anastomosis, forming a 50 cm common channel (Mechanick et al., 2013; Neff et al., 2013). In 1986, Dr. Douglas Sterling Hess modified the procedure with a duodenal switch. The modified technique consists in (1) “preservation of the lesser curvature, antrum, pylorus, and [initial segment of duodenum]” (Anderson et al., 2013), (2) duodenal-ileal anastomosis with vertical, subtotal SG, accompanied by creation of alimentary limb, and (3) reconstruction of the small bowel, with common channel length 100 cm (Mechanick et al., 2013). BPD and BPD/DS are effective procedures, at the cost of micro- and macronutrient deficiencies, protein-caloric malabsorption, and “metabolic derangements, such as iron deficiency anemia, deficiencies in the fat-soluble vitamins (A, D, E, and K), and metabolic bone disease” (Mechanick et al., 2013). Outcomes (weight loss, comorbidities remission and/or improvement, and quality of life for example) in the long term are great in severely obese patients, especially those with BMI >50 kg/m². The superior profile of these procedures, however, are at the expense of increased incidence of gastrointestinal complications and risk of postgastrectomy symptoms, malnutrition, and severe metabolic disturbances. Since the incidence of adverse postoperative complications are relatively high compared to other procedures, BPD and BPD/DS is less often performed by surgeons. Decreasing trends in the utilization of these procedures may also be explained by the surgical complexity and specialist surgical knowledge and training.

**Selection of bariatric procedures.** Determination of the most appropriate surgical procedure often depends less on cost and more on the medical, psychological, and social issues of the patient. Factors identified in the clinical practice guidelines
discussed the current considerations in preoperative decision making and bariatric surgical selection. These include individualized goals of therapy such as weight loss and/or glycemic control, local area bariatric surgeons and institutions in the region, patient preferences, and personalized risk stratification for adverse surgical outcomes (Mechanick et al., 2013). However, there is at present no sufficient “evidence to generalize in favor of one bariatric surgical procedure for the severely obese population” (Mechanick et al., 2013).

The American Association of Clinical Endocrinologists, The Obesity Society, and American Society for Metabolic & Bariatric Surgery (AACE/TOS/ASMBS) recent clinical practice guidelines highlighted two distinct variables that require further considerations in selection of appropriate treatment modality for weight reduction, metabolic control, reversal of metabolic derangements, improvement or resolution of comorbidities, positive psychological changes, and improved quality of life through bariatric surgery. These two variables include metabolic response to surgery and analysis of emerging data in support of clinical safety, durability and effectiveness for that specific procedure and, in addition, treatment outcome data (Mechanick et al., 2013). Genome-wide association studies and other genome-level approaches have identified genetic loci and specific genetic variants, such as single nucleotide polymorphism (SNP) in common obesity. Perhaps the most important finding occurred in 2007, when Fawcett & Barroso (2010) demonstrated that SNPs within the fat mass and obesity-associated (FTO) gene played a key role in energy homeostasis, and thus obesity susceptibility. Although intrinsically useful to localize genetic loci or DNA sequence variants
contributing to obesity, SNPs often fail to explain the diverse heterogeneity of FTO gene polymorphisms, penetrance genetic susceptibility to obesity, allele frequencies, and linkage disequilibrium patterns across different ethnic populations, and therefore may lack clinical predictive power (Blakemore & Froguel, 2010). With advancement of genomics research in the last decade, candidate gene and genome-wide association studies have been undertaken for different Mendelian obesity causative mutations active in the brain and involved in leptin-melanocortin signaling pathway (Blakemore & Froguel, 2010). A small fraction of the severely obese (approximately 5%) demonstrate coding mutations associated with Mendelian or monogenic obesity, but this area of research has still not been explored extensively. Genetic screenings for Mendelian forms of obesity are infrequent; however, hold the promise to improve clinical care among these high-risk patients (Blakemore & Froguel, 2010).

Observational studies, and randomized, controlled trials of population-based samples to examine emerging bariatric surgical procedures, including mini-gastric bypass, distal gastric bypass, biliopancreatic bypass, biliopancreatic bypass with duodenal switch, two-stage bariatric surgery procedures, laparoscopic gastric plication, adjustable gastric banding with existing gastric bypass or sleeve gastrectomy, and endoscopic revision procedures after gastric bypass, warrant further study and are considered investigational (Mechanick et al., 2013; The Regence Group, 2016). The AACE/TOS/ASMBS guidelines however state the potential impact of these bariatric procedures on future decision making.
**Postoperative Risks and Complications**

Postoperatively, patients experience metabolic and nutritional complications that have important clinical implications. During the early post-operative period, abdominal pain, wound infection, gastrointestinal bleeding, pulmonary embolism, staple line leak, and deep venous thrombosis may occur. Late complications include dumping syndrome, short bowel syndrome, nutritional deficiencies, stomal stenosis, cholelithiasis, internal and incisional hernias, bowel obstruction marginal ulcers, and anastomotic strictures. Metabolic complications in the postoperative period include metabolic acidosis, and/or alkalosis, and electrolyte abnormalities (Jammah, 2015). Hypocalcemia, hypokalemia, hypomagnesemia, hyponatremia, and hypophosphatemia are the usual chief electrolyte abnormalities. Nutritional complications may result from anatomical and physiological alterations of the gastrointestinal tract and postoperative dietary changes. Fat-soluble vitamins A, D, E, and K, iron, folic acid, copper, vitamin B12, and thiamin constitute the most frequent deficiencies (Jammah, 2015). In view of vitamin D deficiency and decreased calcium absorption is the presentation of metabolic bone disease after surgery. Bariatric surgery is frequently complicated by vitamin D deficiency, decreased calcium absorption, and secondary hyperparathyroidism, which causes bone disease (osteoporosis and osteoporotic fracture are common), leading to increased risk of morbidity and mortality. Furthermore, bariatric surgery can induce “significant hyperoxaluria and risk of nephrolithiasis” (Whitson et al., 2010), “increase bacterial overgrowth causing nocturnal diarrhea and abdominal distension” (Jammah, 2015), and cause episodes of postprandial hypoglycaemia.
Postoperative Alterations in Physiological and Metabolic Processes

Manipulation of normal gastrointestinal anatomy following RYGB surgery and the gastric sleeve have been shown to affect physiological and metabolic processes that control gut-brain signaling and glycaemia (Ballsmider et al., 2015; Miras & le Roux, 2013; Mosinski & Kirwan, 2016).

Gut-brain communication. Changes in the circulating levels of gastrointestinal hormones post-RYGB and SG operations are known to have an effect on weight loss, as extensively described in the literature (Faurschou et al., 2011; Siejka et al., 2013; Stefater et al., 2012; Wilson-Pérez et al., 2013). However, whereas a great attention has been paid to hormonal changes, the concomitant changes in neural circuits underlying the antiobesity effect have been, until recently, unexplored (Ballsmider et al., 2015). There is evidence suggesting bariatric operations, including the RYGB and SG, have the potential to sensitize abdominal viscera and that sensory information from the gastrointestinal tract, operating via the vagus nerve, is relayed to the brainstem that may modulate vagovagal neurocircuity and reorganize hindbrain feeding centers that influence satiety, control food intake, and regulate glucose homeostasis and gastric motility (Altschuler et al., 1989; Berthoud & Powley, 1992; Berthoud et al., 2011; Campos et al., 2012, 2013; Czaja et al., 2006; Fox et al., 2000; Gallaher et al., 2012; Peters et al., 2013; Wright et al., 2011). Considering this background, Ballsmider and colleagues (2015) specifically investigated vagal innervation, hindbrain reorganization, and microglial changes in vagal structures after bariatric surgical operations (RYGB, SG and sham). Utilizing retrograde neuronal tract tracing methods and fluorescent staining, the study demonstrated that
RYGB and SG in rats induce both vagal afferent neuronal damage and hindbrain reorganization of vagal afferents. However, there was a major difference in the nature of the damage and the effect on hindbrain reorganization.

RYGB-treated rats compared to sham-operated controls showed very few retrogradely labeled neurons in the nodose ganglion (NG) and dorsal motor nucleus (DMV) of the vagus, implicating a compromised retrograde axonal transport in the gastric branch of the vagus nerve and disconnection of vagal signaling from the stomach to the hindbrain. The reduced number of retrogradely labeled neurons in the NG and DMV observed after RYGB represent spared collateral projections to the stomach from celiac and accessory celiac branches of the subdiaphragmatic vagus (Ballsmider et al., 2015; Hayakawa et al., 2013). Assessments of afferent and efferent retrogradely labeled neurons analyzed in both SG- and sham-operated rats revealed no significant differences between these two groups.

Densities of vagal afferents in the nucleus tractus solitarius (NTS) were significantly reduced post-RYGB but unchanged in the DMV compared with their controls (Ballsmider et al., 2015). However, following SG, the densities were significantly higher in the NTS and the DMV than those in the corresponding sham-treated operation. The decreased density of vagal afferents seen following RYGB are consistent with withdrawal and remodeling of central vagal afferent terminals in the NTS after subdiaphragmatic vagotomy (Ballsmider et al., 2015; Peters et al., 2013). The observed RYGB-induced plasticity within the NTS may be partially responsible for
reduction in glutamate release and number of afferent inputs (Ballsmider et al., 2015; Peters et al., 2013).

In rats with SG, the increases in the density of vagal afferents and numbers of retrogradely-labeled neurons observed post-SG are consistent with sprouting (or thickening) of central neurites after sciatic nerve transection (Ballsmider et al., 2015; Lin et al., 2011; White & Kocsis, 2002). The subsequent sprouting of hindbrain neurons may be a contributing factor underlying “hyperexcitation of NTS synapses and increased glutamate release” (Ballsmider et al., 2015). The consequent hyperexcitation of hindbrain feeding circuits offers a plausible mechanism regulating decreased caloric intake and weight loss. This phenomenon remains to be established (Ballsmider et al., 2015).

Qualitative analysis of microglial cells ten days after operation indicated that microglial cells within the hindbrain seem to be more amoeboid (active) (Ballsmider et al., 2015). Microgliosis was readily evident in RYGB rats. This microgliosis in the RYGB rats was associated with microglial morphological changes that were unchanged in SG rats. As compared with sham-operated controls, microglia from RYGB rats show larger soma and thicker, shorter amoeboid processes whereas microglia from sham operated rats was closer to the ramified (rested) morphology (Ballsmider et al., 2015; Badoer, 2010). Further, neuroinflammation was observed in the NTS and DMV. The neuroinflammation caused by damage to the vagal innervation and RYGB-induced activation of microglia is considered to be a functional mechanism regulating appetite
and body weight through stimulation of proinflammatory cytokine release. However, this phenomenon warrants further investigation (Ballsmider et al., 2015).

**Glycemic control.** Although the underlying mechanisms remain elusive, the differential intestinal adaptations occurring after RYGB and SG surgeries are concomitant with an ameliorated glucose tolerance beyond weight loss. In more recent work, Cavin et al. (2016) demonstrated two distinct and rapid adaptations affecting intestinal morphology, glucose handling, and expression of glucose transporters post-RYGB and SG surgery. Consistent with previous reports, histological examination of intestinal mucosa in RYGB rats revealed hypertrophy of the alimentary and common limb with increased mucosal thickness, bowel width, villus height and crypt depth (le Roux et al., 2010; Taqi et al., 2010). Remarkably, and similar to intestinal mucosa from RYGB-operated rats, alimentary and common limb hypertrophy with increased mucosal surface area and crypt depth, but not villus height, were seen in humans after RYGB. These architectural changes explained by gut adaptation were further shown to be associated with local increase in the number of enteroendocrine cells (i.e., glucagon-like peptide 1, GLP-1, and glucose-dependent insulinotropic peptide, GIP) without changing mean cell density. By extension, it is plausible that increased enteroendocrine cells coexpressing GLP-1 and GIP regulate blood glucose concentrations and that GLP-1 through its actions on insulin secretion helps improve blood glucose control after RYGB surgery (Reimann & Gribble, 2016; Salehi & D’Alessio, 2014).

Intestinal hypertrophy, as has been reported in previous rat models of RYGB, also led to increased mucosal crypt cell proliferation (Bueter et al., 2010; le Roux et al., 2010;
Mumphrey et al., 2012; Stearns et al., 2009; Taqi et al., 2010). Cavin et al. (2016) likewise showed increased basolateral GLUT1 expression in the Roux limb of rats after RYGB. This observation suggests that an increase in GLUT1 expression may be sufficient to increase glucose uptake by intestinal epithelial cells, enhancing intestinal disposal of circulating glucose, and thereby improving glycemic control (Cavin et al., 2016). Recent work by Saeidi et al. (2013) supports this observation.

Compared to RYGB, SG-operated rat intestine showed an absence of intestinal morphology. Cross-sectional areas and diameter of the jejunum remained unchanged. There was an increase in villus height but no changes in crypt depth and mean mucosal area. Interestingly, whereas there was no change in the number and density of the cells expressing GIP in the jejunum, the number and density of cells expression GLP-1 appeared to increase without hyperplasia. Further, SG had no significant effect on GLUT1 induction or expression of jejunal sugar transporters (Cavin et al., 2016).

The absence of intestinal hypertrophy triggered by SG does parallel other researcher’s findings, suggesting that neither adaptive hypertrophy nor the reprogramming of intestinal glucose metabolism are necessary prerequisites for either short- and long-term glycemic control (Mumphrey et al., 2015). Consistently, sequestration of alimentary or blood glucose within the jejunal segment from SG remained unaltered. However, SG demonstrated decreased alimentary glucose transport and capacity for absorption within the jejunal segments, whereas increasing blood-to-lumen transepithelial glucose transport (Cavin et al., 2016). There are plausible mechanisms to explain the regulation of glucose tolerance from SG, for example, delayed
entry of alimentary glucose and release of blood glucose into the lumen. However, the origin of this regulation is still unknown (Cavin et al., 2016). This is sustained by the report that delayed glycemic response after an oral glucose load decreases jejunal glucose absorption in rats and humans (Cavin et al., 2016; Jiménez et al., 2015). Taken together, these findings demonstrate that the intestine responds differentially to bariatric surgery, and the intestinal regions also utilize different adaptive mechanisms to regulate glucose transport and thus improve glucose homeostasis.

**Postoperative Clinical Outcomes**

As bariatric surgery can alleviate associated comorbidities and increase physical capacity, postoperative clinical outcomes have become the primary concern. Informing patients of the risks and expected or anticipated benefits before bariatric surgery is ideal, but predicting postoperative outcomes is difficult because of individual prognostic factors (Neff et al., 2013). Furthermore, surgical center, proficiency of the operating surgeon, and type of surgical procedure have been mentioned to be contributing factors underlying variation outcomes after bariatric surgery. Postoperative outcomes after bariatric surgery are presented below.

**Body weight.** Bariatric surgery effectively induces weight loss in patients with morbid obesity; however, the degree of weight loss varies according to type of surgical procedure (Buchwald & Oien, 2009; Reoch et al., 2011; Smith et al., 2011). Compared with other bariatric surgery procedures, duodenal switch surgery induces greater weight loss with the most significant improvements in obesity-related comorbidities but at a potentially greater risk (Buchwald et al., 2004; Laurenius et al., 2010; Søvik et al., 2011).
Duodenal switch and RYGB provide similar levels of improvement in metabolic and quality of life outcomes (Laurenius et al., 2010; Søvik et al., 2011). Amongst the remaining bariatric procedures, RYGB over AGB in most studies achieves superior excess weight loss, peaking at 80% two to three years postoperatively (K. Knopp, personal communication, September 11, 2015; Neff et al., 2013; Tice et al., 2008). At 12 to 36 months postoperative RYGB and SG achieve comparable weight loss but more prospective, long-term data are needed (Kehagias et al., 2011; Yaghoubian et al., 2012).

**Diabetes mellitus.** The presence of obesity increases the risk of diabetes and related metabolic diseases. Compared with conventional medical therapy, bariatric operations demonstrate superior efficacy for insulin sensitivity, glucose control, and diabetes remission independent of weight loss (Dixon et al., 2008; Carlsson et al., 2012; Courcoulas et al., 2014a; Ikramuddin et al., 2013, 2015; Mingrone et al., 2012, 2015; Müller-Stich et al., 2015; Rubino et al., 2016; Schauer et al., 2012, 2014a, 2014b). Rates of diabetes remission or improvements are greatest in patients after duodenal switch, followed by RYGB, and then banding procedures (Buchwald et al., 2009). Remission rates tend to be comparable between RYGB and SG at 12 months follow-up (Benaiges et al., 2011; Karamanakos et al., 2008). Bariatric surgery has been demonstrated to completely resolve diabetes in 72% of patients at two-year follow-up but appears to decrease after ten years (Sjöström et al., 2004). Further studies demonstrate bariatric surgery beneficially reduces diabetes-related mortality (Adams et al., 2007; Buchwald et al., 2009; Dixon et al., 2008; Gill et al., 2010; Sjöström et al., 2007).
The effects of bariatric surgery on diabetes remission cannot, however, be explained by weight loss and caloric restriction alone and may include other mechanisms such as hindgut theory, foregut theory, midgut theory, direct bile acid action, and changes in human microbiota (Basso et al., 2011; Borg et al., 2006; Bose et al., 2009; Cummings et al., 2007; Drucker, 2007; Karamanakos et al., 2008; Liou et al., 2013; Mithieux, 2009; Patti et al., 2009; Pournaras et al., 2012; Rubino et al., 2006; Umeda et al., 2011; Yip et al., 2014). Diabetes duration, use of insulin, HbA1c levels, and presumably, preoperative BMI, may also contribute to the variability in remission rates (Hayes et al., 2011; Kashyap & Schauer, 2012).

**Cardiovascular and cardiac disease.** Obesity associates with an increased mortality and morbidity of cardiovascular sequelae (Wilson et al., 2002). Available data suggests bariatric surgery has marked effect on cardiometabolic risk factors, including hypertension and dyslipidemia and demonstrates marked amelioration of glycemic control and remission from baseline (Adams et al., 2007; Hofsø et al., 2010; Mingrone et al., 2015; Sjöström et al., 2007, 2012, 2014). Further studies implicate bariatric surgery beneficially modulates heart rate variability and QT intervals and also demonstrates beneficial effects on cardiac function, ventricular remodeling, and atherosclerotic load, reversing the detrimental effects of obesity cardiomyopathy (Ashrafian et al., 2008; Bezante et al., 2007; Di Bello et al., 2008; Nault et al., 2007; Papaioannou et al., 2003).

**Airway.** Morbid obesity has been established as increasing apnea frequency and impairing nocturnal pulmonary function, ventilator capacity, and gas exchange (Frey & Pilcher, 2003; Leme Silva et al., 2012; Malhotra & White, 2002; Rajala et al., 1991).
Bariatric surgery is an effective treatment for OSA and has been reported to improve airway responsiveness and lung function in obese asthmatics (Boulet et al., 2012; Greenburg et al., 2009). Surgery can decrease the obesity apnea-hypopnea index (AHI) and demonstrates resolution/improvement in severity of OSA, OSA symptoms and parameters of sleep quality (Buchwald et al., 2004; Foster et al., 2009). Unfortunately, surgical weight loss alone does not reliably cure OSAHS. Against this background, “patients are likely to continue to require treatment” (Lettieri et al., 2008).

**Liver.** Hepatic steatosis, nonalcoholic steatohepatitis (NASH), hepatic fibrosis, and cirrhosis are comorbidities that frequently associate with obesity (Li et al., 2002). Bariatric surgery for morbid obesity beneficially modulates liver histological abnormalities in the great majority of patients, with trends across several studies confirming a marked decrease in serum concentrations of gamma-glutamyltransferase (GGT) and alanine aminotransferase (ALT), reduction in platelet count, and pronounced decrease of liver fat content and inflammation (Chavez-Tapia et al., 2010; Dallal et al., 2012; Johansson et al., 2013; Sakçak et al., 2010; Xourafas et al., 2012). Although a number of studies report on improved or normalized liver histology after surgery, there is the possibility of worsening hepatic fibrosis in the postoperative period (Chavez-Tapia et al., 2010). Patients with hepatic fibrosis may be referred with consideration of bariatric surgery and postoperative follow-up and care (Chavez-Tapia et al., 2010).

**Incidence of rhabdomyolysis.** Dissolution of skeletal muscles with subsequent extravasation of toxic myocyte constituents into the circulation are characteristic of rhabdomyolysis (RML) (Case-Lo, 2014; Visweswaran & Guntupalli, 1999). RML occurs
relatively common, but a highly variable clinical presentation can be seen. Clinical features range from asymptomatic creatine kinase (CK) elevations (hyperckemia) to life-threatening electrolyte imbalance, hypovolemia, metabolic acidosis, coagulopathy, and myoglobinuric renal failure (Dayer-Berenson, 1994; Hunter et al., 2006). Myoglobin-induced acute renal failure occurs in approximately 30% of patients with RML; mortality rates are 20% (Bostanjian et al., 2003; Hamilton et al., 1972). Surgical trauma, postictal state, or extraordinary physical exertion may precede RML. Added factors that could precipitate development of RML include crush injury syndrome, inherited enzymatic deficiencies, endocrinopathies, drugs, toxins, bacterial or viral infections, malignant hyperthermia, neuroleptic malignant syndrome, electrolyte imbalances, diabetic ketoacidosis, and non-ketotic hyperosmolar coma, among others (Cervellin et al., 2009; Dayer-Berenson, 1994; Ito et al., 2012; Koya et al., 2007; Löfberg et al., 2008; Zimmerman & Shen, 2013).

RML has been reported in connection with bariatric surgeries (Bosch et al., 2009; Case-Lo, 2014; Tolone et al., 2016). In bariatric surgery, RML usually occurs as a result of high pressure compression because of prolonged supine positioning and extended operative time, but there are other contributing factors to that should be considered (Benedetto et al., 2010; Collier & Duke, 2003; Lagandré et al., 2006; Tolone et al., 2016). Male gender, advanced age, American Society of Anesthesiologists (ASA) III and IV physical status with BMI >50 kg/m², serum CK levels >5,000 IU/L, presence of diabetes mellitus or hypertension, use of statins, anesthetic drugs and preoperative analgesics (e.g., propofol; barbiturates; salicylates; benzodiazepines; opiates) have been mentioned to be
contributing factors (Lagandré et al., 2006; Stroh et al., 2005; Tolone et al., 2016; Warren et al., 2002). To date, the incidence of RML in bariatric surgery remains unclear and some authors have mentioned a 1.4% to 75% for RML after weight loss surgery (Faintuch et al., 2006; Forestieri et al., 2008; Khurana et al., 2004).

**Changes in gastrointestinal hormones.** The gut-brain axis contributes to regulate appetite and subsequent feeding behavior. Gut-derived hormones are important signals in appetite regulation and can exert either anorexigenic or orexigenic effect on food intake (Gorica et al., 2014). Studies have shown an alteration in gastrointestinal hormone secretion following bariatric surgery (Dirksen et al., 2013; Grong et al., 2015; Jacobsen et al., 2012; Liddle, 1995; Meek et al., 2016; Nausheen et al., 2013; Ockander et al., 2003; Patriti et al., 2005; Peterli et al., 2012; Shak et al., 2008; Sillakivi et al., 2013; Strader et al., 2005; Sundborn et al., 2007; Thaler & Cummings, 2009; Tsoli et al., 2013; Vincent & le Roux, 2008; Yousseif et al., 2014). The hormones reviewed here are gastrin, ghrelin, cholecystokinin, glucagon-like peptide 1 (GLP-1), oxyntomodulin (OXM), and peptide tyrosine-tyrosine (or peptide YY).

**Gastrin.** Gastrin is produced by enteroendocrine G-cells, which are found in highest numbers in the gastric antrum and duodenum (Meek et al., 2016). Gastrin is released in response to nutrient ingestion. Subsequent gastrin release results from direct G-cell nutrient contact (Meek et al., 2016). Its secretion also is altered by gastric distension. It is known to increase production of hydrochloric acid, pepsinogen, pancreatic juices, IF, and bile. Gastrin also promotes satiety and reduces appetite (Meek et al., 2016).
Bariatric surgery has a theoretic potential to cause decreased secretion of gastrin. Procedures such as RYGB produce different nutrient contact with G-cells. There are two prevailing theories to elucidate the mechanism of fade of gastrin-stimulated acid secretion in RYGB: the hindgut hypothesis and foregut hypothesis (Meek et al., 2016). Evidence indicates that the impact of RYGB on gastrin secretion can be explained by enhanced nutrient delivery to the distal intestine (due to intestinal bypass), exclusion of ingested nutrients from duodenum and proximal jejunum, and increased acid production (Meek et al. 2016; Thaler & Cummings, 2009; Yousseif et al., 2014). The resulting increase in acid production in the remnant stomach should accentuate secretion of somatostatin. Somatostatin, a peptide hormone produced primarily in pancreas, the stomach, and duodenum, inhibits gastrin release (Meek et al., 2016). Further support for the fall in gastric secretion post RYGB comes from studies involving obese patients before and within 12 months after surgery (Jacobsen et al., 2012; Sundborn et al., 2007). The pattern of gastrin secretion differs post gastric banding and post SG. The changes in gastrin levels and effect observed at 6 and 12 months are unchanged after gastric banding (Shak et al., 2008). Surgery by SG observed in both rat and human models resulted in greater postprandial gastrin levels (Grong et al., 2015; Sillakivi et al., 2013).

**Ghrelin.** Ghrelin is a 28-amino acid peptide hormone secreted from gastric X/A-like endocrine cells within the gastrointestinal mucosa of humans, as in rodents; substantially lower amounts are found in the small intestine, pituitary, brain, pancreas, kidney, testis, ovary, and placenta (Date et al., 2000; Hosoda et al., 2006). Its expression increases with starvation, cachexia, and anorexia nervosa and decreases with feeding,
hyperglycemia, and obesity. Ghrelin is also detected in the hypothalamic arcuate nucleus (ARC), a key area for appetite regulation (Hosoda et al., 2006). The hypothalamic arcuate neuropeptide Y (NPY) and agouti-related protein (AgRP) neurons mediate the orexigenic and glucoregulatory actions of ghrelin (Suzuki et al., 2012). Two major physiological functions of this hormone are pituitary growth hormone release and central feeding regulation (Hosoda et al., 2006). Ghrelin also functions to increase gastric emptying and gastrointestinal motility.

Furthermore, ghrelin is the endogenous ligand of the growth hormone secretagogue receptor 1a (GHSR-1a), also called the ghrelin receptor (Meek et al., 2016). The GHS-R gene is expressed primarily in the periventricular areas, as well in the ARC of the hypothalamus (Cowley et al., 2003). The acylated form of ghrelin is involved in GHSR-1a activation. Acylated ghrelin exerts an orexigenic effect. Comparing with normal weight individuals, fasting and postprandial ghrelin levels are lower in obese. However, obese individuals exhibit high levels of acylated ghrelin (Meek et al., 2016). The effects of bariatric surgery upon ghrelin is under debate; ghrelin has been shown to increase following gastric banding and decrease following RYGB and SG. It is most likely that anatomical variations of the stomach and degree of contact between the ghrelin cells and nutrients and per surgery are mechanisms that potentially contribute to the different postoperative ghrelin outcomes (Meek et al., 2016).

**Cholecystokinin.** Cholecystokinin (CCK), an anorectic neuropeptide in the human brain, is released postprandially into circulation via enteroendocrine I-cells when high levels of fatty acids or amino acids reach the duodenum (Meek et al., 2016). Levels
generally peak 15 minutes after meal ingestion (Suzuki et al., 2012). CCK in the gastrointestinal tract has an important physiological effect on gastrointestinal motility and gastric emptying (Suzuki et al., 2011). In addition, CCK regulates pancreatic enzyme secretion, gallbladder contraction, gastric acid secretion, and glucose homeostasis (Meek et al., 2016; Suzuki et al., 2012). CCK is also involved in the regulation of food intake and satiety signaling (Meek et al., 2016). Plasma CCK concentrations are elevated in obesity. Following RYGB even with the resection of the gastric fundus and reduced contact with ingested nutrients, there is a postprandial increase in CCK. Besides to established presence of fatty acids and protein within the duodenum, studies strongly suggested that parasympathetic impulses, intra-luminal releasing factors, and changes to duodenal CCK cell density (Liddle, 1995; Ockander et al., 2003). Surgery by SG resulted in greater postprandial CCK levels (Peterli et al., 2012). The effect of gastric banding upon CCK is not fully understood (Meek et al., 2016).

**Glucagon-like peptide-1.** Glucagon-like peptide-1 (GLP-1), an anorectic neuropeptide, is released into the circulation by enteroendocrine L-cells of the distal ileum and colon following nutrient ingestion along with PYY and oxyntomodulin (OXM) (Suzuki et al., 2012). These peptides work synergistically with other postprandial signals originating from the gastrointestinal tract to promote satiety and satiation. Circulating GLP-1 levels are characterized by a fall during fasting periods and postprandial rise (Suzuki et al., 2012). GLP-1 exerts various metabolic effects, including glucose-dependent inhibition of glucagon secretion, glucose-dependent stimulation of insulin secretion, satiety and appetite regulation, and a slowdown of gastric emptying and
intestinal motility (Meek et al., 2016; Suzuki et al., 2012). In addition to its anorectic actions, GLP-1 also exhibits incretin effects (Meek et al., 2016; Suzuki et al., 2012). In normal weight and obese individuals, intravenous GLP-1 administration appears to reduce food intake but responsiveness in the obese is less (Holst, 2007; Verdich et al., 2001).

The GLP-1 receptor, or GLP-1R, is a typical pancreatic beta cell receptor. GLP-1R is most abundant in pancreatic islets, the brain, and gastrointestinal tract (Holst, 2007). There are two biologically active forms (GLP-1_{7-36amide}) identified. GLP-1_{7-36} is mainly found in the central nervous system, while GLP-1_{7-37}, the major circulating form, is located in the paraventricular nucleus of the hypothalamus (PVN), dorsal motor nucleus (DMN), nucleus tractus solitaries (NTS), dorsal vagal complex (DVC), pituitary, and thalamus (Larsen et al., 1997).

Bariatric surgery does not appear to markedly alter fasting concentrations of GLP-1; however, accumulating evidence suggests that surgery can modify postprandial concentrations. All forms of bariatric surgery – gastric banding, RYGB, and SG – have the potential to increase postprandial GLP-1 plasma concentrations (Dirksen et al., 2013; Jacobsen et al., 2012; Tsoli et al., 2013; Yousseif et al., 2014). A potential explanation for postprandial GLP-1 increases following bariatric surgery could be increased ileal nutrient delivery and accelerated intestinal transit of the hindgut (hindgut hypothesis) (Nausheen et al., 2013; Patriti et al., 2005; Strader et al., 2005). The changes in anatomical physiology could also contribute to increased postprandial GLP-1 levels, as duodenal exclusion (foregut hypothesis) can decrease anti-incretin’ factor secretion.
Knowledge about GLP-1’s role in weight loss following bariatric surgery remains poorly understood, despite its association with satiety (Suzuki et al., 2012).

**Oxyntomodulin.** Oxyntomodulin (OXM) is a 37-amino acid peptide that belongs to a family of enteroglucagon peptides including GLP-1 and GLP-2 (Suzuki et al., 2012). OXM is released into the circulation by enteroendocrine L-cells of the distal gastrointestinal tract following food ingestion, in proportion to calories ingested, in parallel with GLP-1 and peptide YY (PYY) (Ghatei et al., 1983; Meek et al., 2016; Suzuki et al., 2012). At the same time, plasma ghrelin is decreased.

In conjunction with postprandial signals arising from the gastrointestinal tract, OXM, GLP-1, and PYY act synergistically to impact favorably on the regulation of satiety, contributing to meal termination and the feeling of hunger (Cummings & Overduin, 2007). The benefits of this effect may, therefore, be related to less weight gain and even some weight loss. Moreover, this effect of OXM, GLP-1, PYY and other postprandial gastrointestinal signals seems to be of additional importance. Accumulating evidence has shown that apart from its anorectic effects on hypothalamic appetite-regulating centers, OXM also associates with postprandial insulin-stimulation and beta cell protection (Schjoldager et al., 1988). In addition to its insulinotropic effect, OXM inhibits gastric acid secretion and delays gastric emptying (Suzuki et al., 2012). Studies by Cohen et al. (2003), Dakin et al. (2001), and Wynne et al. (2006) have shown that administration of OXM to rodents and humans induces negative energy balance by increasing energy expenditure while decreasing food intake and gastric emptying. OXM
is a glucagon and GLP-1 receptor (GLP-1R) agonist (Meek et al., 2016). OXM has a 50-fold lower affinity for the GLP-1R compared with GLP-1, the main incretin hormone (Fehmann, et al., 1994). Like GLP-1, OXM is inactivated by the enzyme dipeptidyl peptidase IV (Suzuki et al., 2012). To date, OXM’s role in bariatric operations is still to be elucidated (Meeks et al., 2016).

Peptide tyrosine-tyrosine. Peptide Tyrosine-Tyrosine, or peptide YY (PYY), expression is mostly restricted to enteroendocrine cells in the distal gastrointestinal mucosa (colon), designated L-cells, but may be found also in regions of the central nervous system, including the hypothalamus, medulla, pons, and spinal cord (De Silva & Bloom, 2012; Ekblad & Sundler, 2002; Meek et al., 2016). PYY functions to increase satiety and decrease food intake. In addition, PYY can induce the following effects: ileal brake, delay gastric emptying, reduce postprandial insulin production, reduce acid secretion, and inhibit gallbladder contraction and exocrine pancreatic secretion (Meek et al., 2016; Sloth et al., 2007; Suzuki et al., 2012). In humans, PYY expressing endocrine cells predominate in the large bowel and the rectum; a limited expression of PYY is found in the duodenum and jejunum (De Silva & Bloom, 2012; Suzuki et al., 2012). Endogenous forms of PYY - PYY₁₋₃₆ and PYY₃₋₃₆ - that serve as hormones are released by the gut and taken up into circulation; PYY₃₋₃₆, the active form of PYY, is the predominant circulating form in both fasted and postprandial states. PYY is found in the circulation in low concentrations in the fasting state. Only when fed or under pharmacological stimuli (e.g., intravenous administration) may its level be increased (Batterham et al., 2002, 2003a; Suzuki et al., 2012). PYY levels in fed individuals
increase rapidly to peak at approximately 01.00 to 02.00 hours. Postprandial PYY release is proportional to caloric load and macronutrient composition of foods eaten and plasma levels remain elevated for up to six hours postprandially (Adrian et al., 1985; DeSilva & Bloom, 2012; Suzuki et al., 2012).

Although conflicting results have been reported, studies of fasting total PYY plasma levels are indicated to be lower in obese and morbidly obese individuals (Ashby & Bloom, 2007; Batterham et al., 2002). Compared with individuals of normal weight, obese individuals demonstrate a reduced sensitivity to the anorectic effect of PYY

\[ \text{PYY}_{3-36} \]

jointly with blunted postprandial elevations of PYY

\[ \text{PYY}_{3-36} \] (Addison et al., 2011). In obese rodents, intermittent intraperitoneal PYY

\[ \text{PYY}_{3-36} \] administration can produce sustained reductions in food intake, body weight, and body fat mass (Chelikani et al., 2007). Increased PYY levels and markedly improved glucose homeostasis after bariatric surgery have been reported (Meek et al., 2016). These effects manifest within two weeks after surgery, and remain comparable 12 months after surgery (Dirksen et al., 2013; Jacobsen et al., 2012).

**Other gut hormones.** Several other gastrointestinal hormones and peptides may mediate the beneficial effects of bariatric surgery, or may be altered postoperatively (Meek et al., 2016). The hormones and peptides reviewed here are secretin, vasoactive intestinal polypeptide (VIP), pancreatic polypeptide (PP), insulin, glucagon, somatostatin, and obestatin.

Secretin is a 27-amino acid peptide hormone released from duodenal mucosa S-cells into circulation when intraluminal pH is low. Secretin acts to stimulate pancreatic
bicarbonate production and reduce gastric acid secretion. It also functions to reduce
gastric and duodenal motility, inhibit gastrin release, and promote insulin release (Meek
et al., 2016).

VIP is a 28-amino acid peptide released from enteric nerves and parasympathetic
efferent nerve fibers (Meek et al., 2016). Vagal stimulation appears to affect VIP
secretion. VIP functions to stimulate the secretion of electrolytes and water into
pancreatic juice and gut lumen (Meek et al., 2016). In addition, VIP can induce the
following effects: reduce gastric acid production, relaxation of vascular and
gastrointestinal smooth muscle, and promote hormone release from the hypothalamus,
gut, and pancreas. Knowledge about fasting or postprandial somatostatin and VIP levels
post-surgery has yet to be elucidated fully (Meek et al., 2016).

PP is a 36-amino acid peptide synthesized and released postprandially by the F-
cells of the islets Langerhans into circulation. PP acts on Y4 receptors in the
hypothalamus and brainstem to reduce appetite (Suzuki et al., 2012). Expression of PP is
most abundant in the duodenal portion (the head) of the pancreas (Ekblad & Sundler,
2002). Amounts of PP are found also in the gastrointestinal tract, colon and rectum,
though to a lesser extent (Ekblad & Sundler, 2002). PP affinity for the Y4 is high.
Expressions of Y4 subtype receptors are widely distributed within the central nervous
system, including the area postrema (AP), the nucleus tractus solitarius (NTS), dorsal
motor nucleus of vagus (DMV), the paraventricular nucleus (PVN) and the arcuate
nucleus (ARC) of the brain hypothalamus (Parker & Herzog, 1999; Suzuki et al., 2012).
PP exhibits an orexigenic effect in addition to its anorectic action. These effects are dependent upon the route of administration (Suzuki et al., 2012). Centrally administered PP is associated with increased appetite, food intake, and gastric motility in both mice and humans (Clark et al., 1984; Suzuki et al., 2012). Peripheral administration of PP is associated with reduced food intake and body weight, delayed gastric emptying, and increased energy expenditure (Asakawa et al., 2003). In both lean and obese humans, administrations of PP via the peripheral route are associated with reduced appetite and food intake (Batterham et al., 2003b).

Diurnal variation of circulating PP concentrations has been documented. Levels peak at 21:00 hours, with levels returning to initial fasting concentration approximately five hours later (Track et al., 1980). Diurnal variations in PP secretion occur independently of TFF2, a gastric cytoprotective trefoil protein. PP diurnal rhythm appears to be mostly mediated by CCK and gastrin receptors on the vagal nerve (Suzuki et al., 2012; Williams, 2014). PP concentrations in the pancreas increase in response to ingestion of a high protein meal, peaking at approximately 15 to 30 minutes (Williams, 2014). The sustained phase is lower, lasting approximately four to six hours after feeding (Suzuki et al., 2012; Williams, 2014). Circulating levels of PP are found to be lower in obese individuals, though studies have yielded inconsistent results (Glaser et al., 1988; Jorde & Burrhol, 1984; Lassman et al., 1980; Wisen et al., 1992). The effects of bariatric surgery upon PP remains to be unknown at this time (Meek et al., 2016).

Insulin is a 51-amino acid peptide hormone mainly synthesized and secreted by the beta cells of the pancreas in response to elevated levels of blood glucose (Meek et al.,
2016). It is released during the fed state and acts to decrease blood glucose levels by promoting glycogenesis. Insulin also stores glucose in liver, skeletal muscle, and adipose tissue to be used for energy when required. Insulin restores normal levels of blood glucose by stimulating the uptake of glucose, amino acids, and lipids (Gropper & Smith, 2012). T2DM associates with deficient insulin secretion or beta cell dysfunction. These are hallmark characteristics in most obese individuals with increased requirements of insulin (Meek et al., 2016).

RYGB and SG operations appear to have different effects upon insulin secretion (Meek et al., 2016). Concentrations of insulin remain unchanged after gastric banding while concentrations of insulin decrease significantly after RYGB and SG (Falkén et al., 2011; Mallipedhi et al., 2014; Shak et al., 2008). Studies of the effects of bariatric surgery for obesity in the context of postprandial enteroglucagon (GLP-1 and OXM) responses and temporal changes in glucose and insulin homeostasis in patients with dysglycemia (impaired glucose tolerance and/or impaired fasting glucose) and T2DM, RYGB and SG were able to improve insulin sensitivity and postoperative incretin hormone response. So, in aggregate, RYGB and SG may show effectiveness in glycemic control, which influence T2DM risk favorably (Falkén et al., 2011; Mallipedhi et al., 2014). Of particular relevance, surgery by RYGB results in improved pancreatic islet beta cell function (Falkén et al., 2011; Jørgensen et al., 2012; Umeda et al., 2011).

Glucagon, like insulin, is released from cells of the pancreatic islets in response to levels of blood glucose. In response to lowered blood glucose levels the alpha cells of the pancreas release glucagon, a 29-amino acid peptide hormone. Glucagon, released
during the fasting state, acts to increase blood glucose levels by stimulating the breakdown of glycogen stored in the liver and activating gluconeogenesis by increasing cAMP concentrations and levels of active protein kinase A (Meek et al., 2016).

Reduction of circulating glucagon levels are observed with weight loss. Although this effect on glucagon concentrations seems important in terms of possible prevention of excessive hepatic glucose output and diabetes complications, there are few studies of the effect of bariatric procedures upon plasma glucagon concentrations in humans and needs further investigation (Meek et al., 2016).

Somatostatin is a peptide hormone which is derived from posttranslational cleavage of prosomatostatin (Francis et al., 1990). Somatostatin is the main inhibitory peptide of acid secretion (Schubert & Peura, 2008). The preprohormone is expressed in the pancreas, the stomach, and duodenum (Meek et al., 2016). Somatostatin induces the following effects: inhibition of parietal cell signaling, and inhibition of histamine and gastrin release (Athmann et al., 2000; Nylander et al., 1985; Schubert et al., 1989). It also functions to regulate hormones in the gastrointestinal tract, pituitary, and pancreas. Somatostatin secretion is subject to the control of gastric acid and gastrin. It increased by VIP activation and suppressed by cholinergic activation (Mejia & Kraft, 2009).

Administration of somatostatin reportedly inhibits plasma PYY secretion in obese women (Rigamonti et al., 2011). Knowledge about somatostatins role following bariatric surgery and the contribution of the gastrointestinal tract to circulating somatostatin still remains unclear (Meek et al., 2016).
Obestatin is a 23-amino acid peptide hormone secreted from the stomach. Obestatin, which like gastrin, PYY, CCK, PP, GLP-1, and oxyntomodulin, has been implicated as a satiety peptide/anorectic hormone to suppress food intake and reduce body weight gain in rodents. Obestatin is also involved in the delay of gastric emptying gastrointestinal transit of food (Lacquaniti et al., 2011; Suzuki et al., 2012). Despite its demonstrated anorectic effects, the exact anorectic pathways through which obestatin functions to control appetite, and influence food intake and body weight in lean or obese rodents have, however, yet to be clarified (Gourcerol et al., 2007; Lacquaniti et al., 2011). The effect of bariatric surgery on obestatin is unknown (Meek et al., 2016).

Preoperative Preparation and Postoperative Care in Bariatric Surgery

The section that follows will discuss the preoperative preparation and postoperative care in bariatric surgery.

Current Standards, Protocols, and Best Practices in Bariatric Surgery

The Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) was a program developed in 2012 to advance safe, high-quality care for bariatric surgery patients (ACS & ASMBS, 2016). The MBSAQIP evolved from the collaboration of the American College of Surgeons (ACS) and the ASMBS, and is an outcomes-based initiative to measure and compare bariatric surgical safety and quality between institutions in the United States and Canada. In 2016, the ACS and ASMBS published its updated MBSAQIP Standards for optimal care of the metabolic and bariatric surgery patient (ACS & ASMBS, 2016). The Standards provide a nationally
consistent and uniform set of measures of safety and quality for application in bariatric surgery care throughout the perioperative period.

Under the Standards, both the ACS and ASMBS require established perioperative protocols that facilitate standardization of care related to the bariatric surgical procedure. In addition, the ACS and ASMBS require the use of comprehensive protocols that outline the continuum of care of the bariatric surgery patient. Protocols are formal pathways that integrate evidence-based recommendations and algorithms for a specific patient population with a predictable clinical course (Prasad et al., 2010). Protocols might be particularly helpful in bariatric surgery because they can define, optimize, and sequence different tasks performed by members of the multidisciplinary team (ACS & ASMBS, 2016). The multidisciplinary team includes surgeons, anesthesiologists, nurses, psychologists, dietitians, and medical subspecialties as clinically indicated. The implementation of protocols for use in the perioperative care has been associated with improved outcomes in bariatric surgery patients and significant savings to the health-care system (Campillo-Soto et al., 2008; El Chaar et al., 2014; Frutos et al., 2007; Huerta et al., 2001; Yeats et al., 2005).

Published protocols and algorithms on perioperative care in bariatric surgery remain limited (Campillo-Soto et al., 2008, Frutos et al., 2007; Huerta et al., 2001; Yeats et al., 2005). Multiple organizations and societies have compiled the available evidence into management guidelines since 2005 (Fried et al., 2007, 2013; Heber et al., 2010; Mechanick et al., 2008, 2013; NICE, 2016; SAGES, 2008; Sauerland et al., 2005). The AACE, in conjunction with TOS and the ASMBS have established best practices
governing the perioperative nutritional, metabolic, and nonsurgical support and care of
the bariatric patients (Mechanick et al., 2008, 2013). Aills et al. (2008) have previously
proposed guidelines for optimal nutritional care of bariatric patients. Both of these
guidelines are meant to looked upon as instruments to guide practitioners and should
neither be interpreted as standards of care nor intended to substitute clinical judgement.
Any clinical decision by practitioners should be adjusted in view of individual patient
circumstances and local resources (Mechanick et al., 2008, 2013).

**Preoperative Evaluation and Management of Potential Bariatric Candidates**

Candidates for bariatric surgery must undergo routine preoperative
multidisciplinary evaluation before the prior approval request for surgery. It is
considered a part of preoperative evaluation to identify correctable medical
abnormalities, stratify risk, discuss choices of surgeon and medical institution, direct
anesthetic choices, provide details of surgical options, process, risks and benefits, and
guide postoperative management (Eldar et al., 2011; Mechanick et al., 2013). At a
minimum, the clinical practice guidelines of the AACE/TOS/ASMBS indicate that a
preoperative evaluation should include comprehensive review of medical, psychosocial,
and medication history by the bariatric surgeon; appropriate physical examination; review
of diagnostic data (laboratory, electrocardiograms, chest radiographs, pulmonary function
tests, spirometry, gastrointestinal and endocrine evaluations); nutrient screening; clinical
nutrition evaluation by the bariatric dietitian; psychological assessment; anesthesia
consultation; and consultations with medical subspecialties (endocrinology, cardiology,
respiratory medicine) as clinically indicated (Eldar et al., 2011; Marques, 2015;
Mechanick et al., 2013). Specific pathways are developed for the preoperative assessment of candidates deemed general low-risk, high-risk medical, high-risk psychological, and revisional bariatric surgery and are largely institution-specific (Eldar et al., 2011).

Preoperative nutritional assessment is increasingly recognized as an essential component of perioperative care for the bariatric surgical patient. Although no standard of best practice yet exists for preoperative nutrition assessment and care of surgical candidates, current clinical practice guidelines outline the critical elements for assessment and the functions the assessment must serve (Aills et al., 2008). In general, the nutritional assessment involves two parts: a clinical interview and evaluation of objective and subjective data. Each surgical candidate meets with a qualified registered bariatric dietitian for a clinical interview that focuses on behavioral patterns, psychological health (current/past), and understanding of the surgery and commitment to the long-term follow-up plan (Aills et al., 2008; Jensen et al., 2014; Marques, 2015; Mechanick et al., 2013; Tsigos et al., 2008). Surgical candidates then complete a comprehensive nutritional assessment, which provides objective and subjective measures of their nutritional status, identifies nutritional and educational needs, and determines surgical suitability, preoperative preparation/management, and readiness for surgery (Aills et al., 2008; O’Kane, 2016). According to ASMBS Allied Health Nutritional Guidelines, this process should include, as a minimum, thorough history and physical examination, review of anthropometric data, and baseline laboratory investigation (Aills et al., 2008). The history should include information about medical diagnoses, medical tests and surgical
procedures, hospitalizations, social supports and history (alcohol/tobacco/drug use), and psychiatric symptoms (current/past). The history should also include past diet history, changes in appetite and intake, and gastrointestinal symptoms that may affect nutritional status. Medications (including OTC medications) and supplements (vitamin, mineral, and herbal) should be noted; food allergies/intolerances documented. A nutrition-focused physical assessment should be performed to define nutritional status and risk and identify characteristics of malnutrition/other nutrition-related problems (AND, 2013). When nutritional deficiencies are identified, patients should receive correction with appropriate supplementation and/or food (Aills et al., 2008; Marques, 2015). Poor preoperative nutritional status is a strong predictor of postoperative nutritional deficits (Ben-Porat et al., 2015).

Laboratory investigations prior to bariatric surgery are an important part of preoperative evaluation to detect subclinical nutritional deficiencies (Aills et al., 2008; Alvarez-Leite, 2004; Ben-Porat et al., 2015; Ernst et al., 2009a; Heber et al., 2010; Shah et al., 2011; Xanthakos & Inge, 2006). Clinical guidelines recommend to include a baseline lipid panel, comprehensive metabolic panel, lipid profile, urine analysis, prothrombin time/international normalized ratio, complete blood count, and nutrient screening, with more extensive testing dictated by surgical procedure and patient clinical indications (Aills et al., 2008; Mechanick et al., 2008, 2013). There is limited evidence, at this time, for recommending routine preoperative testing as part of the preoperative examination, but are generally considered reasonable for the bariatric surgical patient (Apfelbaum et al., 2012; Heber et al., 2013; Mechanick et al., 2008, 2013).
In anticipation of surgery, bariatric dietitians should explore behavioral patterns through inquiries about previous attempts at weight loss (e.g., past treatments, patterns of weight loss/maintenance/gain, reasons for failed weight loss attempts), eating habits (e.g., binge eating, bulimia, stress-related eating, emotional eating, nighttime eating), physical activity (e.g., assess patient’s ability to incorporate exercise into daily routine), and substance abuse (current/past) (Aills et al., 2008). Multiple reports have shown an association between binge eating disorder and poor weight loss outcomes after surgery in bariatric patients (Alger-Mayer et al., 2009; Conceição et al., 2013; Tanofsky-Kraff et al., 2013). Patients requiring specialized physical activity instruction and/or presenting with eating disorders (active or known history of) will need referral for further evaluation (Aills et al., 2008). The bariatric dietitian should also work with the patient to optimize dietary intake.

In addition, cognition, motivational readiness, and emotional aspects should be explored: knowledge should be assessed (the patient should understand surgery and postsurgery lifestyle requirements and understand surgery guidelines (i.e., preoperative diet preparation; lifestyle changes; postoperative diet phases; timing/dosage of required supplements); moreover, patients should be educated on best rapid-recovery diets, weight loss, and maintenance; individual needs and patient motivation/readiness for change should be evaluated; personal barriers (e.g., lack of stable support system; financial constraints) to postoperative success should be identified; patients should recognize and address their emotional connections with food and develop strategies to eliminate maladaptive eating behaviors (Aills et al., 2008; Marques, 2015; Mechanick et al., 2013;
Snyder-Marlow et al., 2010). The patient’s current life situation, including lifestyle, physical activity, stressors (internal and external), support system, work schedule, occupation, socioeconomic status, marital status/children, and family food cultures and traditions, should be also evaluated (Aills et al., 2008).

Beyond anthropometric measurement, biochemical assays, clinical examination, and dietary evaluation, nutritional assessment constitutes an opportunity to prepare prospective surgical candidates by addressing concerns, issues, challenges, and knowledge deficits, to give education, to provide counseling, to better manage nutrition-related comorbidities, to avoid postoperative nutrition-related complications, to optimize postsurgical outcomes and to enhance long-term weight loss maintenance (Aills et al., 2008; Tempest, 2012).

In preparation for surgery, patients are obligated to attend weight loss surgery seminars and participate in a medically supervised weight loss program. Lifestyle education and nutrition-behavior change sessions are conducted by the bariatric dietitian and/or another member of the bariatric surgery team and are delivered in a group format. Patients generally receive in-depth instruction of all the postoperative nutrition recommendations.

The preparation for bariatric surgery is important and therefore incumbent upon bariatric dietitians to ensure that all patients undergoing surgery receive effective teaching and education beforehand. Nutrition education taught by the bariatric dietitian should detail specific dietary and lifestyle changes. Education should accentuate personal responsibility, discuss self-monitoring techniques and benefits of regular physical
activity, review preoperative diet preparation and postoperative diet in terms of advancement, texture progression, nutrient and daily fluid intake, eating behavior, and supplementation, and technique and tips to maximize food and fluid tolerance (Aills et al., 2008). Preoperative nutrition education also should approach anticipated surgical results, ensure patients do not hold false expectations, and establish/reinforce goals of care (Aills et al., 2008). In addition, guidelines for continued weight loss should be reviewed both in the pre- and postoperative period. A review of guidelines before surgery can help patients increase their understanding, facilitate dietary adherence, encourage satisfaction, and address questions and concerns (Leahy & Luning, 2015). For surgeries with either a malabsorptive or gastric restrictive component, the bariatric dietitian will provide guidance as the meal plan is progressed (Kulick et al., 2010). Nutrition education by the bariatric dietitian is mandatory for all patients. Nutrition education and counseling should be individually tailored. Frequent counseling is encouraged “to reinforce nutrition education, behavior modification, and principles of self-care” (Aills et al., 2008).

Guidelines for Patient Selection

AACE/TOS/ASMBS 2008 guidelines provide patient selection criteria for bariatric procedures including laparoscopic RYGB, SG, AGB, and BPD/DS. The following criteria (for patients aged 18 to 60 years) provide information in determining whether a patient is a candidate for bariatric surgery:

- “BMI ≥40 kg/m² with no comorbidities;
- BMI ≥35 kg/m² with obesity-associated comorbidity;
• Failure of previous nonsurgical attempts at weight reduction, including nonprofessional programs [and failure to maintain long-term weight loss];

• Expectation that patient will adhere to postoperative care. This includes follow-up visits with physician(s) and team member, recommended medical management and use of dietary supplements, and instructions regarding any recommended procedures or tests” (Mechanick et al., 2008).

The aforementioned criteria serve as indications for surgery, provided the following contraindications are absent: alcohol abuse and/or drug dependencies; non-stabilized psychotic disorders; clinical depression; personality disorders; presence of eating disorders; uncorrectable coagulopathy; conditions carrying surgical and anaesthetical risks; limited life expectancy due to metastatic or inoperable malignant tumor(s), or irreversible cardiopulmonary failure; reversible endocrine disorders; lack of comprehension in regard to details of the surgery (such as operative risks/benefits, expected outcomes, alternatives, lifestyle changes) (Fried et al., 2013; Mechanick et al., 2008, 2013; Provost, 2014).

**Challenges with Candidate Selection**

Selection of candidates for bariatric surgery comes with challenges that the bariatric surgery team must grapple with. Identified challenges include weight/BMI, weight loss history, patient commitment, exclusions related to surgical risk. Weight/BMI is routinely used to assess suitable candidates for bariatric surgery. Current AACE/TOS/ASMBS guidelines support the surgical indication for patients with BMI ≥40 kg/m² without comorbidities, or BMI between 35 and 39 kg/m² with clinically
significant obesity-related comorbidities (cardiovascular, metabolic, pulmonary, endocrine, hematopoietic, gastrointestinal/hepatobiliary, genitourinary, obstetric/gynecologic, musculoskeletal, neurological, psychological) (Brethauer et al., 2006; Mechanick et al., 2008, 2013). Patients at very high or prohibitive operative risk, including those with cardiopulmonary disease, coagulopathies, or conditions carrying substantial surgical/anaesthetical risk or threatening life in the short term, are deemed inoperable (Fried et al., 2013; Mechanick et al., 2013; Provost et al., 2014). Those with untreated, severe psychosis, clinical depression and personality disorders, and eating behaviors that are emotionally driven (e.g., binge eating; grazing; night eating syndrome) are relative contraindications to surgery, as is drug and alcohol dependence (LeMont et al., 2004). When there are concerns about compliance with medical treatment, understanding about the surgical procedure and post-surgical guidelines, adherence to self-management regimens and lifestyle and nutritional recommendations (i.e. vitamin/mineral supplementation, pre- and postoperative dietary instructions), and continued commitment to sustain new behaviors and participate in follow-up, bariatric surgery may not be appropriate (LeMont et al., 2004; Mechanick et al., 2013). Patients with peptic ulcer disease and patients who are pregnant or are planning to become pregnant 12 months pre-surgery are likely to have their operation postponed (Provost, 2014).

**Medical Clearance**

In general, surgeons periodically identify patients who are candidates for bariatric surgery; however, symptoms or risk factors identified in the preoperative evaluation may
warrant medical clearance. The purpose of medical clearance of candidates selected for bariatric surgery is to determine the stability of patients' mental, cardiovascular, and respiratory status, whether patients are in optimal medical condition to undergo surgery, and eligibility. Most often surgeons will refer bariatric surgery candidate patients to a primary care physician to obtain medical clearance. From a medical perspective, medical clearance prior to surgery is essential; helps surgeons identify preexisting conditions that may otherwise increase perioperative risk. The provision of medical clearance incorporates set guidelines and requirements. The following briefly describes each of these guidelines and requirements:

- **Optimized preoperative glycemic control.** Implementation of a comprehensive diabetes mellitus (DM) care plan in the preoperative period is recommended. For prospective bariatric surgery candidates with DM, the following glucose goals should be considered: hemoglobin A1c values between 6.5 and 7.0% or less; a fasting blood glucose ≤110 mg/dL; and a two-hour postprandial glucose concentration ≤140 mg/dL. Reduction in glycemic burden months before surgery may translate better clinical outcomes for bariatric patients (Fenske et al., 2011; Perna et al., 2010; Rometo & Korytkowski, 2016; Zaman et al., 2017). More liberal preoperative targets (A1c 7 to 8%) is recommended for patients with advanced micro- and macrovascular complications, extensive comorbid conditions, or long-standing DM as advocated by the American Association of Clinical Endocrinologists and American College of Endocrinology. Need for bariatric surgery should be based on reasonable clinical judgement in high-risk
patients (those with A1c >8% or otherwise uncontrolled DM) (Mechanick et al., 2013).

- Routine preoperative screening for primary hypothyroidism is not recommended; however, a thyroid-stimulating hormone (TSH) blood test will be ordered in patients identified at risk for primary hypothyroidism. If hypothyroidism is confirmed, patients will be treated with levothyroxine monotherapy.

- Patients with obesity are advised to obtain a fasting lipid panel. The National Cholesterol Education Program (NCEP) Adult Treatment Panel guidelines will be used to evaluate lipid levels and determine treatment.

- Per AACE/TOS/ASMBS guidelines, women are highly advised to delay pregnancy for 12 to 18 months after surgery. The rationale behind this recommendation is related to the rapid phase of weight loss and increased stress on the organism (Wittgrove et al., 1998). Although risk to the mother and fetus is relatively low, malnutrition does involve the potential for intrauterine growth restriction (or small-for-gestation age), fetal growth restriction in women with prior bariatric surgery to pregnancy, and preterm labor and premature rupture of membranes (KJÆR & Nilas, 2013). Pregnancy after bariatric surgery often presents complex medical challenges. It is highly recommended that women have nutritional surveillance and laboratory screenings for deficiencies each trimester. Further, it is recommended that women be counseled about nutritional supplementation and contraceptive choice postoperatively, be monitored for appropriate weight gain and for fetal health, and informed about how surgery may
affect future pregnancies (Mechanick et al., 2013). For pregnancy after bariatric surgery, postoperative care and follow-up by a multidisciplinary team, which includes an obstetrician, skilled nursing staff, an endocrinologist, an internal medicine specialist, bariatric surgeon, and a bariatric dietitian, is recommended. In the first period after RYGB or malabsorptive operations, patients should consider non-oral contraceptives as many patients experience changes in absorption that could affect the permeability and solubility of the drug (Sawaya et al., 2012). Pregnant women who have undergone LAGB may have the band adjusted to facilitate “appropriate weight gain for fetal health” (Mechanick et al., 2013).

- Discontinuation of estrogen therapy before bariatric surgery to prevent postoperative thromboembolic phenomena.
- Women with polycystic ovarian syndrome (PCOS) should be advised that fertility may improve after bariatric surgery.
- Case-by-case decision making regarding screening for rare causes of obesity should be based on specific clinical history and physical findings.
- Beyond electrocardiogram as preoperative assessment, noninvasive cardiac testing is determined according to individual risk factors and historical and physical examination findings. In patients that present with known history of cardiovascular disease, formal preoperative cardiology consultation may be indicated. It is suggested that at-risk patients be evaluated for perioperative beta-adrenergic blockade.
• Before the proposed surgical procedure, it is suggested that chest radiograph and screening for obstructive sleep apnea (OSA) be performed, but may require confirmatory polysomnography with positive screening results. In patients with intrinsic lung disease or disordered sleep patterns being considered for bariatric surgery, formal evaluation of pulmonary function with measurement of arterial blood gases is recommended.

• Diagnostic assessment of deep vein thrombosis (DVT) in patients with documented history of DVT or cor pulmonale is recommended. A concerning issue is the use of prophylactic inferior vena cava (IVC) filters in patients with prior history of DVT or pulmonary embolism (PE). Prophylactic IVC filter placement are thought to place patients at high risk for adverse complications (i.e., filter-related thrombosis) or death (Mechanick et al., 2013).

• Preoperative gastrointestinal assessment. The assessment may include imaging studies, upper gastrointestinal series, or endoscopy.

• Routine preoperative abdominal ultrasound for liver disease is not recommended.

• Routine preoperative Helicobacter pylori screening, especially in geographical, high-prevalence areas.

• Provision of prophylactic treatment for patients with known history of gout to prevent occurrence of gouty attack.

• Outside National Osteoporosis Foundation clinical practice guideline recommendations, data are insufficient and do not yet warrant routine evaluation
of preoperative fracture risk and changes in bone mineral density overtime using dual energy x-ray absorptiometry.

- Preoperative psychosocial-behavioral evaluation. Patients with “known or suspected psychiatric illness, or substance abuse, or dependence should undergo formal mental health evaluation” (Mechanick et al., 2013). Patients identified as “high-risk” who underwent RYGB should eliminate alcohol consumption.

- Preoperative evaluation of the patient’s ability to incorporate nutritional and behavior changes before and after surgery.

- Preoperative nutritional evaluation and treatment of malnutrition. Considerations for perioperative nutritional evaluations are dependent on the performed type of surgical procedure. Malabsorptive bariatric procedures require more extensive evaluation.

- Preoperative assessment by the patient’s primary care physician.

- Preoperative risk assessment for cancer.

**Preoperative Nutrition Care**

Preoperative nutrition care of the bariatric surgical patient consisting of nutrition risk screening and stratification, micronutrient supplementation, diet regimens, and weight loss requirements are described below.

**Preoperative nutrition risk screening and stratification.** Nutritional depletion is pervasive in morbidly obese preoperative candidates and is a well-recognized complication of bariatric surgery (Aills et al., 2008; Ben-Porat et al., 2015; Mechanick et al., 2013; Peterson et al., 2016). Nutritional screening on admission as well as
postsurgery can be used to further stratify nutritional risk or malnutrition in these patients. Nutritional risk stratification in surgical care is supported by current literature (Bozzetti et al., 2007; Grass et al., 2011; Hiesmayr et al., 2009; Kassin et al., 2012; Schiesser et al., 2008; Schindler et al., 2010; Sorensen et al., 2008; Sun et al., 2015). Nutritional risk is a modifiable risk factor and can be improved by nutritional support (Lawson & Daley, 2015; Sun et al., 2015). Early identification of nutritional risk and prompt treatment with repletion regimens, either by diet or supplementation, have been established showing decreased risk of serious postoperative complications (Aills et al., 2008; DiGiorgi et al., 2008; Jie et al., 2012; Mahdy et al., 2008; Peterson et al., 2016).

**Preoperative micronutrient supplementation.** Poor preoperative nutritional status is a strong predictor of postoperative nutritional deficits (Ben-Porat et al., 2015). Micronutrient supplementation should be provided to obese patients presenting with subclinical deficiencies to prevent, retard, or minimize debilitating, even life-threatening nutritional deficiencies in the postoperative period (Aills et al., 2008; Ben-Porat et al., 2015). However, correction of micronutrient deficiencies in the preoperative period, while of critical importance, is often left untreated in the bariatric surgical candidate (Aills et al., 2008; Ben-Porat et al., 2015). Schiavo et al. (2016) demonstrated that a 10-week course of preoperative micronutrient supplementation effectively treats micronutrient deficiencies in morbidly obese candidates scheduled for bariatric surgery. Crowley et al. (2015) reported significant improvements in nutritional status and post readmission rates after supplementation of micronutrient over 60-days. These studies indicated that preoperative supplementation programs improved postoperative
micronutrient deficiencies even in the short term; however, its impact on micronutrient
deficiencies in the long term are still an important issue that requires further
investigation.

**Preoperative diet regimens.** With respect to medical nutrition therapy, the
treatment plan for prospective candidates varies case by case but the main goals are to
facilitate nutritional well-being, reduce body fat, preserve lean body mass, protect muscle
tissue postsurgery, improve surgical outcomes and recovery, and prepare the patient for
the postsurgical diet. Current guidelines recommend preoperative restriction of dietary
energy plus the recommended daily intake of vitamins, minerals, and trace elements
among obese patients scheduled for bariatric surgery. Low-calorie diets (LCD) that
contain between 800 and 1,500 calories/day or very low-calorie diets (VLCD) that
contain between 450 and 800 calories/day given prior to surgery have proven to produce
weight loss and decrease in liver and intra-abdominal fat volume (Colles et al., 2006;
Edholm et al., 2015; Faria et al., 2015; Fris, 2004). Currently, there are two types of
LCD and VLCD: normal consistency with nutrient supplementation and diets in the form
of liquid meal replacements (Faria, 2015). LCD or VLCD liquid meal replacement diets
may be considered two- to four-weeks before surgery. This protocol has been shown to
minimize surgical risk and reduce postoperative complications in patients undergoing
bariatric surgery (Colles et al., 2006; Mechanick et al., 2013). The mechanism of action
seems to be not only a reversal in steatohepatitis, but primarily a reduced liver size and
intra-abdominal fat (Fris, 2004). With the diminished liver size and intra-abdominal fat
content, a good surgical field visualization of the gastro-esophageal area can be secured
(Fris, 2004). Although the literature suggests potential benefit with diets in the form of liquid meal replacements, the optimal dietary regimen or duration of a diet has not been established (Kim et al., 2016).

**Preoperative weight loss requirements.** In 2011, the ASMBS published a position statement on preoperative weight loss requirements (Brethauer et al., 2011). Two weight management initiatives have been proposed: physician-mandated weight loss and insurance-mandated weight loss. Physician-mandated preoperative weight loss has been suggested along with a minimum weight loss threshold of 5% to 10% of initial body weight immediately (one or two months) before bariatric surgery, citing improvements in surgical risk, reduction in technical complexity via a better visualization, reduced rate of postoperative complications, and better weight loss short-term as evidence for this contention (Alvarado et al., 2005; Benotti et al., 2009; Collins et al., 2011; DeMaria et al., 2007a, 2007b; Eisenberg et al., 2009; Gerber et al., 2015; Huerta et al., 2008; Kulick et al., 2010; Liu et al., 2005; Still et al., 2007). However, published data at the present time are of low-level evidence and are contradictory, in part due to methodological differences between studies (Brethauer, 2011; Gerber et al., 2015). As for insurance-mandated preoperative weight loss requirements, there is no high-level evidence to support this practice (Brethauer, 2011; Kim et al., 2016). The current Position Statement of ASMBS concludes that insurance-mandated preoperative weight loss is not effective for preoperative weight loss before surgery and does not provide any postoperative outcomes benefit (Kim et al., 2016). The practice of insurance-mandated weight loss is not only scientifically unfounded but may well do more harm than good as it has
contributed to the attrition of patients from bariatric surgery programs, has caused unnecessary delay with life-saving treatment, and has led to the negative progression of comorbid conditions (Brethauer et al., 2011; Kim et al., 2016). Where preoperative weight loss is indicated, consideration of specific needs and circumstances of the patients is suggested (Brethauer, 2011; Kim et al., 2016). Preoperative requirements may be at the discretion of the individual surgeon and/or institution (Ochner et al., 2012).

**Postoperative Nutrition Care**

The points of the postoperative nutrition care for bariatric patients are as follows: (1) Postoperative nutritional management and (2) Postoperative follow-up.

**Postoperative nutritional management.** Traditional postoperative management begins with clinical monitoring of laboratory parameters, followed by a clear liquid diet that is advanced to regular solid foods as tolerated (Aills et al., 2008; Heber et al., 2010; Kulick et al., 2010). In the obese patient, the goals of postoperative nutritional management are to “maximize weight loss and absorption of nutrients, maintain adequate hydration, and avoid vomiting and dumping syndrome” (Bosnic et al., 2014). Guidelines on nutrition care for postoperative bariatric patients generally focus on dietary progression and nutritional supplementation from the immediate postoperative period, to six months after surgery, then long-term maintenance and support thereafter (Moizé et al., 2010). The prescribed diet for bariatric patients after surgery comprises eating five to six half volume meals spread over the day; separating foods from liquids; consuming adequate protein and fluid; eating slowly and chewing foods thoroughly; and avoiding simple sugars and concentrated sweets (Aills et al., 2008; Kulick et al., 2010).
**Laboratory monitoring.** Patients who have undergone bariatric surgery should receive routine clinical and biochemical monitoring for detection of subclinical micronutritional and macronutritional deficiencies and prevention of frank deficiencies according to existing guidelines (Heber et al., 2010; Mechanick et al., 2013). Several laboratory investigations including analysis of lipid panels, clinical chemistry (liver and kidney function tests), and complete blood count, comprehensive metabolic panel, lipid profile, urinalysis, analysis of prothrombin time/international normalized ratio, and nutrient screening are recommended after bariatric surgery (Heber et al., 2010; Mechanick et al., 2013). During the postoperative period, laboratory investigations are repeated periodically with variable frequencies according to type of bariatric surgery. Guidelines advise laboratory investigations in the immediate postoperative period (one month after surgery), at three month intervals until stable, and then annually thereafter (Heber et al., 2010; Mechanick et al., 2013). Frequencies of laboratory screens could be an important quality metric for this patient population (Tsai et al., 2014).

**Postoperative diet stages and progression.** The AACE/TOS/ASMBS guidelines recommend the use of a staged protocol-based meal progression (Mechanick et al., 2013). Instructional content of the postoperative diet stages specific to the patient’s procedure is also recommended. These instructions should be given to the patients before surgery (Bosnic, 2014; Mechanick et al., 2013).

During a six- to eight-week period, patients progress through five diet stages: clear liquids, full liquids, pureed, mechanically-altered soft foods, and firmer, regular foods. The purpose of the texture progression in all cases is to prevent unnecessary
gastrointestinal symptoms (e.g., nausea/vomiting; epigastric discomfort; diarrhea; heartburn/acid regurgitation) and enhance healing; in the case of LRYGB and LSG, to preserve the staple line (Aills et al., 2008). The duration of each phase depends on the patient’s needs and tolerance (Aills et al., 2008; Snyder-Marlow et al., 2010).

There may be variations to the diet progression for different surgery types. The progression reviewed here is for both LRYGB and LSG because these operations are the most commonly practiced in the United States. The progression referenced in this thesis is borrowed from the Center for Bariatric Surgery at St. Vincent Charity Medical Center in Cleveland, Ohio. Because nutritional guidelines cannot account for every clinical variation during the postoperative period, the clinician must exercise good professional judgment before advancing the diet.

Postoperative days 1 and 2. For the immediate period after surgery (day one), patients are made NPO. In the first day after surgery, patients should receive intravenous hydration, according to the guidelines established by the AACE/TOS/ASMBS. Only after passing the upper gastrointestinal test may patients be given water and ice chips on days one and two postoperatively. A clear liquid diet should be initiated within the first 24 hours after surgery once a swallow protocol is passed and the patient’s clinical condition remains stable. The clear liquid (with no sugar, no carbonation, and no caffeine) diet should supply fluids and electrolytes (Aills et al., 2008). Liquids should be consumed with small sips in the amount tolerated by the patient. Patients are generally advised to sip one-fluid ounce of recommended clear liquids per hour for the first four hours, and then slowly increase to four ounces of liquid/hour, progressing one fluid ounce
hourly, as tolerated (Kulick et al., 2010). Final liquid intake should be around 48 to 64 fluid oz/day (or 1,500 to 1,900 mL/day) (Kulick et al., 2010). Acceptable clear liquids include sugar-free gelatin/Jell-O, broth, sugar-free popsicles, decaffeinated beverages (e.g., tea; coffee; herbal tea), allowed beverages made with artificial sweeteners (i.e., Sweet ‘N Low, Equal, NutraSweet, Splenda, Sunette, SweetOne), and protein supplements. Other acceptable clear liquids include water, flavored water (e.g., Propel; Vitamin Water Zero; Sobe Water; Fruit 2.0), unsweetened or no sugar added diluted fruit juice, Crystal Lite, powder packages of True Lemon, Lime and salty liquids (e.g., tomato or V-8 Juice). Patients should sip fluids when fully awake after surgery and can only be discharged if satisfactorily tolerating oral fluids. Drinking with a straw is not recommended; large amounts of air may be swallowed, causing pressure and abdominal discomfort (Kulick et al., 2010). Before patients are discharged, the physician’s assistant and bariatric dietitian will discuss home-going instructions. Patients will be discharged on a full liquid (sugar free or low sugar) diet.

Stage II discharge diet – full liquids. In the first week (or day 3) after surgery, patients can begin a full liquid diet. During the full liquid phase of the diet, liquids must be thin, smooth and free of any particles (bumps, lumps, skins, seeds), and all liquids must be thin enough to be taken through a thin (stirrer-type) straw. AACE/TOS/ASMBS guidelines recommend that patients substitute half of calorie-free liquids with high-protein liquids in addition to high-protein whey or soy supplements (Kulick et al., 2010). Recommended fluid for adequate hydration is 48 to 64 oz/day (Kulick et al., 2010). Acceptable full liquids include milk, milk products, and milk alternatives (e.g.,
unsweetened almond or soy milk), other liquids that contain solutes, vegetable juice, strained and thinned soups and broths, cream cereals, protein shakes/supplements, Carnation Instant Breakfast (no sugar added), sugar free popsicles (no fruit chunks), and Powerade/Gatorade Zero. Drinking herbal drinks, adding herbal supplements to beverages, and drinking alcohol are ill-advised during this time. The use of alcohol is ill-advised during the rapid weight loss period and after bariatric surgery due to the rapid rate of alcohol absorption, heightened blood alcohol content, and possible defects in alcohol clearance. Protein supplements (e.g., whey or soy protein powder) may be added to full liquids in amounts of 20 gm at a time (Aills et al., 2008; Kulick et al., 2010). Per AACE/TOS/ASMBS guidelines, patients may begin with multivitamin/mineral supplementation (Kulick et al., 2010; Mechanick et al., 2008). Full liquid diets are most commonly recommended for 10 to 14 days (Aills et al., 2008).

Stage III pureed diet. Two weeks postoperatively, patients can begin to add pureed foods (Aills et al., 2008; Kulick et al., 2010). The pureed diet consists of blended or liquefied foods that provides adequate fluid. During the pureed phase of the diet, foods generally have a smooth texture that is either a consistency of baby food or applesauce, be low in fat and sugar, and be free of any particles (lumps, strings, seeds). Foods commonly included in the puree phase are scrambled eggs and egg substitutes, pureed lean meats, canned fish (tuna or salmon), flaked fish and meat alternatives, poultry, cooked beans, milk, soft cheeses, and hot cereal, and sugar-free and low-fat gelatin, popsicles, custard and pudding (Aills et al., 2008; Kulick et al., 2010). In the fourth week after surgery, soft, ripe fruit and boiled, soft vegetables may be introduced;
however, protein should be consumed first (Aills et al., 2008; Kulick et al., 2010). Patients should continue to consume protein supplements to meet minimum daily protein requirements (between 60 to 80 gm/day) (Kulick et al., 2010). Restricting fluid intake before, with, and immediately (approximately 30 minutes) after meals or snacks is also recommended. The bariatric pureed diet by most programs is recommended usually for 10 to 14 days (Aills et al., 2008).

**Stage IV mechanically-altered soft diet.** This phase of the diet serves as a transition from pureed textures to solid textures. Foods are modified in texture and consistency but not flavor. To make chewing and swallowing more comfortable, meats, poultry, and fish may be cooked, ground, minced, flaked, or moistened with sauce or gravy, and fruits and vegetables may be soft-cooked or pureed. Theoretically this diet allows food to pass more easily from the gastric pouch directly into the jejunum (Aills et al., 2008).

**Stage V regular foods (maintenance).** Stage V of the diet (regular foods), the last stage of the recovery period, starts approximately six to eight weeks after surgery. This phase of the diet is generally unrestricted; however, some tenants of weight loss success will need to be followed by patients including sugar, fat, and/or fiber restrictions (Aills et al., 2008). The regular diet incorporates a variety of nutrient-dense foods: lean meat, poultry or fish, whole-grains, low-fat dairy, vegetables, and fruits (Kulick et al., 2010). Protein foods should be eaten with priority; a minimum of 60 gm of protein should be ingested daily to avoid malnutrition (Kulick et al., 2010). Raw fruits and vegetables with high fibrous consistency (raspberries, pears/apple with skin, oranges, celery stalks,
artichokes, broccoli, corn) should be avoided; however, may consume if pureed or well-cooked (Kulick et al., 2010). Meal plan ideally calls for three meals and two snacks per day with portion size limit to no more than one-cup. Recommended fluid (clear liquids) for adequate hydration is 48 to 64 ounces per day (or 1,500 to 1,900 mL per day), waiting at least 30 minutes between meals (Aills et al., 2008; Kulick et al., 2010).

**Postoperative nutrient requirements.** The nutritional requirements of the postsurgical bariatric patient are made up of the following components: energy, protein, carbohydrate, lipids (fat), and fluid.

**Energy (calorie) requirements.** Current ASMBS clinical guidelines indicate that postoperative nutritional support for bariatric patients includes a period of negative energy balance during the rapid weight loss period followed by dietary control for long-term weight loss maintenance and prevention of weight regain (Faria et al., 2010, 2011; Mechanick et al., 2008, 2013; Raftopoulous et al., 2011). In response to negative energy balance however, sufficient energy must be supplied to spare protein for tissue protein synthesis (Wong, 2011).

During the postoperative period, gradual progression of calorie intake has been recommended. While patients may be submitted to different procedures, their capacity for food intake is generally low postoperatively (Brolin et al., 1994). In the first six months postoperatively, patients have been commenced on caloric intakes in the range of 800 to 1,000 calories/day (Carrasco et al., 2007; Brolin et al., 1994; Moizé et al., 2003). By one year postoperative, there is a slight increase in patients’ caloric intake followed with a stabilization in caloric intake with patients consuming between 1,000 and 1,400
calories/day (Brolin et al., 1994; Faria et al., 2013; Olbers et al., 2006). It is worth noting, however, that caloric intake may increase more over time, reaching levels close to 1,800 or 2,000 calories daily (Tsia & Wadden, 2006; Wardé-Kamar et al., 2004). Energy requirements vary and thus are best determined by individual assessment (e.g., clinical status and degree of stress). Prediction equations (i.e., Mifflin St. Jeor) are commonly used in this patient population after extreme weight loss (Frankenfield et al., 2005; Oliveria et al., 2012); however, accuracy of these equation vary and “do not account for body composition which can impact energy requirement” (Johnson Stoklossa & Atwal, 2013).

**Protein requirements.** Adequate protein intake is crucial both in the early and late postoperative period due to concerns of protein malnutrition (albumin <3.5 mg/dL) (Heber et al., 2010). All postoperative patients risk developing protein malnutrition (PM); however, patients submitted to malabsorptive surgical procedures (RYGB and BPD/DS) present greater risk (Heber et al., 2010). Protein malnutrition has been found three to six months after surgery and is largely attributed to inadequate intakes of high-quality protein related to food intolerance and decreased caloric intake (Andreu et al., 2010; Bock, 2003; Faria et al., 2010, 2011; Heber et al., 2010; Moizé et al., 2003). Other mechanisms include malabsorption, extensive gastric restriction, reduction production of hydrochloric acid and pepsinogen, and changes in admixture of gastro-pancreatic enzymes leading to impaired or delayed protein digestion (Bojsen-Møller et al., 2015; Faria et al., 2011; Handzlik-Orlik et al., 2015; Mechanick et al., 2013; Neff et al., 2013).
Current clinical practice recommendations for protein intake in patients without postsurgical complications are in accordance with medically supervised protein-sparing modified fasts (Aills et al., 2008). The nutritional intake of 70 gm of protein/day has been called on very-low-calorie diets, but most programs recommend protein intake in the range of 60 to 80 gm/day, or 1.0 to 1.5 gm/kg IBW with higher amounts up to 2.1 gm of protein/kg IBW assessed on an individual basis (Aills et al., 2008; Bosnic et al., 2014; Heber et al., 2010; Mahan & Escott-Stump, 2000; Mechanick et al., 2013). This translates to about 20% to 30% of calories from protein. A protein intake of 1.5 gm/kg is usually sufficient to maintain positive nitrogen balance and lean body mass during weight loss (Heber et al., 2010; Moizé et al., 2003). Long-term non-critically ill, post-bariatric patients often benefit from protein intake between 60 and 120 gm/day (Aills et al., 2008; Heber et al., 2010; Mechanick et al., 2008). The protein consumed should be of high biological value (e.g., meat, poultry, fish, eggs, milk, soy, etc.) and sources should be varied (Faria et al., 2011). Consensus guidelines recommend 20 to 30 gm of protein per meal (Aills et al., 2008; Faria et al., 2011; Kulick et al., 2010).

Frequently, concerns are expressed about the potential untoward side effects of high-protein intakes; however, exact protein levels needed for this patient population have not yet been defined (Aills et al., 2008). It is important to bear in mind that daily protein consumption >1.5 gm/kg IBW after the early postoperative phase may displace and “prevent the consumption other macronutrients in the context of volume restriction” (Aills et al., 2008). For the noncomplicated patient, a 1.5 gm/kg IBW may exceed their metabolic requirements (Aills et al., 2008).
Oral liquid or powder protein supplements have been recommended during the early postoperative period after bariatric surgery in patients who fail to consume adequate protein in their diets (Aills et al., 2008; Andreu et al., 2010; Castellanos et al., 2006; Faria et al., 2011). The AACE/TOS/ASMBS recommends that modular protein supplements be consumed to complement the patient’s postoperative diet. Four categories of protein supplements are available: milk-derived whey isolate, and casein, egg, and soy protein isolate; collagen derived-isolate either alone or in combination with complete proteins; doses of one or more nonessential amino acids; and mixtures of complete or collagen-based proteins with doses of amino acid (Aills et al., 2008; Andreu et al., 2010; Castellanos et al., 2006; Faria et al., 2011; Heber et al., 2010). Hemp and other high-quality vegan protein powders (e.g., reinforced pea protein) are also available for vegan patients and individuals who may avoid whey or soy due to allergies or intolerances (Furtado, 2012). Protein supplements inclusive of all the indispensable amino acids (histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine) are generally used in cases where weight loss is rapid and protein supplements provide the main source of dietary protein intake (Aills et al., 2008).

**Carbohydrate and lipid (fat) requirements.** Once energy and protein requirements are established, dietary carbohydrate and fat needs are determined. While currently there are no consensus on exact levels needed for the bariatric patient population, most programs recommend a maximum consumption of 130 gm/day of carbohydrate to prevent ketosis and a maximum of 30 gm/day of lipid to prevent EFA deficiency (Wong, 2011).
Fluid requirements. Adequate hydration is an essential part of postoperative care to maintain fluid and biochemical balance, as well as to prevent dehydration. For the bariatric surgery patient, this is especially important. According to current clinical practice guidelines, a 1,500 to 1,900 mL/day fluid restriction is recommended (Kulick et al., 2010; Mechanick et al., 2008, 2013). These recommendations should be adjusted based on the patient’s clinical status. In clinical practice, it is not uncommon to see readmission for dehydration after bariatric surgery. Concerns about limited stomach capacity, reduced postoperative fluid deficits, volume depletion, and poor fluid tolerance are all issues that are thought to account for dehydration post-operation. Hydration must be monitored closely as with energy and protein.

Micronutrient supplementation. Most of the patients undergoing bariatric surgery will develop some nutritional deficiency, justifying multivitamin-mineral supplementation to all obese patients postoperatively (Aills et al., 2008; Alvarez-Leite, 2004; Majumder et al., 2013; Mechanick et al., 2013; Saltzman & Karl, 2013). The current literature suggests potential benefit to postoperative nutritional supplementation in postoperative patients in terms of defined clinical outcomes such as prevention of severe micronutrient deficiencies, enhanced weight loss, and regulation of appropriate body weight (Aills et al., 2008). The suggested regimen for nutritional supplementation following bariatric surgery are given in recent guidelines issued by the ASMBS (Aills et al., 2008). Clinically relevant micronutrient deficiencies as well as standard vitamin/mineral supplementation requirements after gastric bypass and gastric sleeve procedures (Table 1) are presented.
Thiamin (vitamin B1). Deficiencies in thiamin are rare but have been reported after LRYGB and LSG (Bernert et al., 2007; Heber et al., 2010; Jeong et al., 2011). Thiamin is a water-soluble vitamin that is absorbed preferentially in the proximal jejunum (Brolin et al., 1992; Kalfarentzos et al., 1999). Thiamin is an important coenzyme for metabolic reactions involved in glucose metabolism as well as a key component in the biosynthesis of the neurotransmitters acetylcholine and serotonin (Jeong et al., 2011). Acute or chronic thiamin deficiency has been associated with peripheral neuropathy, polyradiculoneuropathy, Wernicke’s encephalopathy, and Korsakoff’s psychoses (Carrodeguas et al., 2005; Flanbaum et al., 2006; Gollobin & Marcus, 2002; Koffman et al., 2006; National Institutes of Health, 2016; Nautiyal et al., 2004; Seehra et al., 1996; Sola et al., 2003). When it occurs, acute neurologic disorders secondary to thiamin deficiency are generally observed at one to three months after surgery; however, can appear as early as six weeks (Abarbanel et al., 1987; Fawcett et al., 1984; Feit et al., 1982; Kramer & Locke, 1987; MacLean et al., 1983; Mason, 1998; Oczkowski & Kertesz, 1985; Paulson et al., 1985; Singh & Nautiyal, 2005; Somer et al., 1985; Villar & Ranne, 1984). The mechanism is related to inadequate vitamin repletion and persistent, intractable vomiting, usually due to stomal stenosis after LRYGB and gastroparesis after LSG (Aills et al., 2008; Heber et al., 2010; Mejia, 1992; Shuster & Vázquez, 2005; Singh & Nautiyal, 2005). Additional contributing factors to thiamin deficiency include malabsorption due to duodenal-jejunal bypass; reconstruction of the duodeno-jejunal passage; a thiamin-poor diet; noncompliance with supplementation
regimen; a high-carbohydrate diet; excessive alcohol consumption; anorexia; and bulimia (Aills et al., 2008).

The standard dosage for mild thiamin deficiency and associated neurologic disease is 100 mg intravenously or intramuscularly once daily for 7- to 14-days, followed by 10 to 30 mg orally once daily until improvement (Aills et al., 2008; Chaves et al., 2002; Heber et al., 2010; Heye et al., 1994; Kushner, 2000; Mechanick et al., 2008; Primavera et al., 1993; Rindi et al., 1996). If Wernicke-Korsakoff syndrome is identified, intravenous thiamin 500 mg three times daily may be indicated. In cases of advanced neuropathy or protracted vomiting, thiamin (intravenous or intramuscular) 50 to 100 mg once daily should be considered (Aills et al., 2008; Heber et al., 2010; Matrana & Davis, 2009; Mechanick et al., 2008; Rhode & MacLean, 2000). The suggested supplementation in asymptomatic postsurgical patients is a standard multivitamin formulation containing 100% daily value (DV) thiamin (Aills et al., 2008).

**Cobalamin (vitamin B12).** Cobalamin (vitamin B12) deficiency is frequent in Patients post-LRYGB, with incidence rates as high as 40% at postoperative year one and 37% by year two and four (Aills et al., 2008; Brolin et al., 2002; Cooper et al., 1999; Halverson, 1986; Heber et al., 2010; Kalfarentzos et al, 1999; Marcuard et al., 1989; Skroubis et al., 2002). Vitamin B12 deficiency also has been reported in cases after LSG (Gehrer et al., 2010). Most vitamin B12 absorption takes place in the terminal ileum bound to IF (Aills et al., 2008; Kulick et al., 2010). B12 deficiency is recognized as a cause of late-onset anemia (Vargas-Ruiz et al., 2008). Low vitamin B12 levels have been found six months after surgery but may not appear for one to nine years as liver stores
become depleted (Aills et al., 2008; Alvarez-Leite, 2004; Brolin et al., 1998a). Deficient vitamin B12 levels after LRYGB have been associated with impaired hydrolysis of protein-bound B12 under hypochlorhydric conditions, insufficient secretion of IF, or defects in IF-vitamin B12 complexes (Aills et al., 2008; Behrs et al., 1994; Carrodeguas et al., 2005; Crowley et al., 1984; Halverson, 1986; Heber et al., 2010; Provenzale et al., 1992; Smith et al., 1993). Low levels of vitamin B12 after LSG are related to fundus resection, decreased production of hydrochloric acid, and reduced production of IF (Craggs-Dino, 2014). Additional contributing factors to B12 deficiency include malabsorption due to inadequate IF; disease of terminal ileum; a long-term vegan diet; medications (metformin, colchicines, neomycin, proton pump inhibitors, anticonvulsant agents); and deficient B12 status preoperatively (Aills et al., 2008).

Described treatments of vitamin B12 deficiency include 350 to 500 mcg daily of oral crystalline vitamin B12 (cyanocobalamin); 1,000 mcg monthly (or 3,000 mcg every six months) of cyanocobalamin by intramuscular injection; or local sublingual (500 to 1,000 mcg/day) and nasal (500 mcg/week) preparations (Aills et al., 2008; Heber et al., 2010; Kuzminski et al., 1998; Rhode et al., 1995, 1996; Vargas-Ruiz et al., 2008).

*Folate.* Fewer deficiencies of folate are seen after LSG compared to LRYGB; however, the reported incidence is highly variable (6% to 65%) (Aills et al., 2008; Boylan et al., 1988; Dixon et al., 2001; Gehrer et al., 2010; MacLean et al., 1983). Folate deficiency is related primarily to inadequate dietary intake, but malabsorption (post-LRYGB), medications (anticonvulsants, oral contraceptives, cancer treating agents), and noncompliance with multivitamin supplementation may play a role (Aills et al., 2008;
Folate deficiency has been associated with peripheral neuropathy, myelopathy, megaloblastic anemia, and neural tube defects (in infants born to mothers who had undergone LRYGB) (Boylan et al., 1988; Knudsen & Kallen, 1986; Martin et al., 1988; Moliterno et al., 2008; Shah et al., 2011).

Regardless of preparation, daily supplementation of folic acid, 400 mcg in multivitamin, is efficacious in correcting folate deficiency (Aills et al., 2008; Brolin et al., 1991; Heber et al., 2010; Kushner, 2000; Matrana & Davis, 2009; Park et al., 2009; Skroubis et al., 2002). LRYGB patients should aim to consume 200% of the DV (800 mcg) of folic acid daily (Aills et al., 2008). An oral dose of 1,000 mcg daily has been proposed to treat folate deficiency but higher daily doses of folic acid (>1,000 mcg) are not recommended since such levels can potentially mask underlying B12 deficiency and lead to neurological damage (Aills et al., 2008; Elliot, 2003; Matrana & Davis, 2009; Shah et al., 2011). Folic acid supplementation should be supplemented in all women of childbearing age to reduce the risk of fetal neural tube defects.

Iron. Iron deficiency (ID) is a well-recognized occurrence after LRYGB and LSG operations and can manifest as anemia (IDA) (Aills et al., 2008; Craggs-Dino, 2014; Crowley et al., 1984; Heber et al., 2010; Saltzman et al., 2005). In postsurgical patients, LRYGB-associated IDA appears to be driven in part by iron malabsorption and alterations in digestion (Topart, 2008; Tovey & Clark, 1980). Other mechanisms, such as presurgical nutritional deficiencies, reduced food intake and intolerance of iron-rich foods (e.g., red meat), gastrointestinal and menstrual blood loss, inadequate supplementation, bacterial overgrowth and the induction of an iron-losing enteropathy,
may also contribute to the observed negative iron balance after surgery (Avinoah et al., 1992; Gopaluni et al., 2012; Toskes, 1976). Malabsorption of iron develops due to exclusion of the duodenum and reduction of gastric acid secretion, causing impaired conversion of nonheme iron to the ferrous form for absorption (Avinoah et al., 1992; Avgerinos et al., 2010; Harbottle, 2011; Mechanick et al., 2008; Munoz et al., 2009). As regards LSG, negative iron balance is likely related to duodeno-jejunal passage reconstruction and inadequate dietary intake.

The standard therapy for iron deficiency anemia (IDA) is 150 to 200 elemental iron (in diet and as supplement) daily in divided doses (three to four tablets/day on empty stomach) plus 500 mg ascorbic acid (vitamin C) daily (Aills et al., 2008; Mechanick et al., 2013; Schrier et al., 2016). Administration of oral iron is well tolerated as first-line therapy for IDA, and an effective strategy provided the dose and duration are adequate (Schrier et al., 2016). Numerous oral iron preparations are available in the United States: ferrous sulfate, ferrous fumarate, ferrous gluconate, and polysaccharide iron complex. The dosing regimen should be guided by “patient age, the estimated iron deficit, the rapidity with which it needs to be corrected, and side effects” (Schrier et al., 2016). For menstruating women and adolescents of both sexes, additional supplementation of iron in combination with the iron found in two multivitamins may be required to achieve an intake of 50 to 100 mg elemental iron per day (Aills et al., 2008; Brolin et al., 1998a, 1998b). In patients submitted to LRYGB, the therapy should include an additional supplementation of 18 to 27 mg/day of elemental iron (Aills et al., 2008). Lower requirements for supplemental iron are advised in women taking oral contraceptives. The
suggested supplementation in asymptomatic postsurgical patients (includes men and postmenopausal women) is two complete multivitamin formulations, collectively providing 36 mg of iron (Aills et al., 2008). Usually, every two to three weeks on iron therapy, with assumed adherence to the regimen, hemoglobin levels of 1 g/dL should occur (Killip et al., 2007). Once levels of hemoglobin normalize, preparations of oral iron should be continued for three months in patients to adequately replenish iron stores. In cases of chronic uncorrectable bleeding, malabsorption, oral iron intolerance, or severe anemia (hemoglobin <6 g/dL) intravenous iron should be considered (Aills et al., 2008; Killip et al., 2007).

*Vitamin D and calcium.* Vitamin D deficiency is more commonly seen with LRYGB, occurring in percentage up to 80% one year after surgery (Aills et al., 2008; Bal et al., 2012; Goldner et al., 2009; Heber et al., 2010; Shah et al., 2011). Vitamin D is a fat-soluble vitamin that is absorbed in the jejunum and ileum (Aills et al., 2008). 1,25-dihydroxyvitamin D is the metabolically active form of vitamin D; it is essential in many physiological processes, including calcium absorption, maintenance of bone mineralization via the regulation of calcium/phosphorous homeostasis, and regulation of innate and adaptive immunity (Khan & Fabian, 2010; Linus Pauling Institute, 2014). Vitamin D deficiency can result in reduced absorption of calcium from the gut and/or elevations of parathyroid hormone (PTH), leading to an increased risk of subsequent hypocalcemia and secondary hyperparathyroidism, respectively (Aills et al., 2008; Heber et al., 2010; Khan & Fabian, 2010; Lips, 2012; Shah et al., 2011). Vitamin D deficiency can manifest as metabolic disease (osteoporosis, osteomalacia), as well as autoimmune
diseases involving T-helper type 1 lymphocyte (multiple sclerosis, rheumatoid arthritis, type 1 diabetes, psoriasis, systemic lupus erythematosus) (Adorini & Penna, 2008; Aills et al., 2008; Bischoff et al., 1999; Bischoff-Ferrari et al., 2005; Collazo-Clavell et al., 2004; DiSepio & Chandraratna, 2000; Khan & Fabian, 2010; Lips, 1996; Mohr et al., 2008; Munger et al., 2006; Patel et al., 2007; Tanghetti, 2009; Wu et al., 2009; Zold et al., 2008). In addition, low levels of vitamin D have been associated with metabolic syndrome, hypertension, and peripheral vascular disease (Giovannucci et al., 2008; Holik, 2005; Kendrick et al., 2009; Kilkkinen et al., 2009; Peterlik & Cross, 2005; Pilz et al., 2009).

Although the mechanisms of low vitamin D levels after LSG are not fully established, there are hypotheses to explain vitamin D depletion after LRYGB. Vitamin D deficiency is aggravated by deficient vitamin D status preoperatively, decreased dietary intake of calcium and vitamin D rich foods, and lactose intolerance (Aills et al., 2008; Lips, 2012). Small intestinal bacterial overgrowth (SIBO) in the blind loops can lead to vitamin D malabsorption (DiBaise, 2008; Scarlata, 2011). However, alterations in digestion and impaired vitamin D absorption are likely the main contributors to vitamin D deficiency after LRYGB. Malabsorption of vitamin D possibly results from the short common channel, deconjugation of bile salts, reduction of gastric acid, and duodenal-jejunal bypass (Aills et al. 2008; Aron-Wisnewsky et al., 2016; Scarlata, 2011; Shah et al., 2011).

The standard therapy to correct vitamin D deficiency is a cholecalciferol (vitamin D3) regimen of 50,000 IU once weekly for eight weeks plus elemental calcium 1,000 to
2,000 mg daily (Aills et al., 2008; Heber et al., 2010; Tripkovic et al., 2012). This regimen is required to maintain serum 25(OH)D levels at or above 50 nmol/L. In cases of severe vitamin D deficiency where rapid correction of deficiency is required, a cholecalciferol loading dose regimen, followed by regular maintenance therapy, should be considered (Aspray et al., 2014; Francis et al., 2013). As regards elemental calcium, guidelines recommend a dose of at least 1,500 mg/day (with at least 800 mg D3 twice daily) post-LRYGB and 1,200 mg (with at least 400 D3 mg twice daily) post-LSG from all sources (food and supplement) (Aills et al., 2008; Mechanick et al., 2013; Snyder-Marlow et al., 2010). Combined dietary and supplemental calcium intake >1,700 mg/day may be required to prevent bone loss during rapid weight loss. For supplementation, calcium citrate preparations are preferred and should be taken in amounts of 500 to 600 mg at one time. Because calcium supplement absorption can be impacted by ingesting iron, calcium and iron supplements should be taken ≥2 hours apart. Patients should wait ≥2 hours after taking multivitamin or iron supplement because the iron and calcium are absorbed by the same receptors in the intestinal tract and compete for absorption sites and can cause gastrointestinal intolerance (Aills et al., 2008).

**Vitamin A.** Although most patients remain asymptomatic, vitamin A deficiencies are not uncommon after LRYGB procedures; vitamin A deficiencies are more commonly associated with malabsorptive procedures (BPD/DS) (Aills et al., 2008; Heber et al., 2010). The mechanism is related to poor nutritional intake, malabsorption, maldigestion, and defects in hepatic retinol release (Heber et al., 2010; Zalesin et al., 2011). If there is concern, consideration should be given to monitoring vitamin A levels until symptoms
resolve. A daily oral starting dose of 5,000 to 10,000 IU vitamin A is currently recommended to normalize serum retinol concentrations (Aills et al., 2008; Heber et al., 2010). IM administration of vitamin A, 10,000 to 20,000 IU/day, may be indicated if oral therapy is neither feasible nor sufficiently absorbed (Aills et al., 2008). Women desiring to become pregnant after bariatric surgery should be advised to avoid taking multiple prenatal vitamins to prevent ingesting excessive nutrients, specifically, vitamin A doses >5,000 IU/day may be teratogenic (Lito, 2008).

*Copper and zinc.* Deficiencies of trace elements copper and zinc in the postoperative period are not uncommon, especially after LRYGB as copper is absorbed in the stomach and proximal duodenum and zinc is absorbed in the duodenum and proximal jejunum (Papamargaritis et al., 2015; Shankar et al., 2010). Copper deficiency may manifest as hematologic disorders (sideroblastic anemia, myelodysplasia, leukopenia/neutropenia), and as demyelinating myeloneuropathy, resembling B12 deficiency (Btaiche et al., 2011; Choi & Strum, 2010; Gletsu-Miller et al., 2012; Goldberg et al., 2008; Green, 2012; Juhasz-Pocsine et al., 2007; Prodan et al., 2009; Shankar et al., 2010; Yarandi et al., 2014). Zinc deficiency has been associated with bullous-pustular dermatitis, diarrhea, intercurrent infection, and hypogonadism in males (Lewandowsk et al., 2007; Papamargaritis et al., 2015; Shankar et al., 2010). Few studies have reported copper/zinc deficits in postsurgical patients (Ernst et al., 2009b; Papamargaritis et al., 2015; Sallé et al., 2010). Although deficiencies of trace elements are rare preoperatively, there is a tendency for serum copper and zinc concentrations to decline in the postoperative period (Papamargaritis et al., 2015). Deficiencies in copper
at postoperative year one have been observed in up to 5% of patients while deficiencies in zinc have been observed in up to 15% of patients one year after surgery (Papamargaritis et al., 2015).

Evidence in the literature posits that extra zinc supplementation at nutritional doses around the RDA might be efficacious in preventing zinc deficiency (Gletsu-Miller & Wright, 2013; Hoffman et al., 1988; Papamargaritis et al., 2015). At amounts well in excess of the RDA, zinc supplementation may however “lead to the sequestration of copper in gut enterocytes due to the zinc-induced upregulation of metallothionein, which binds copper and prevents uptake into circulation” (Gletsu-Miller & Wright, 2013). In other words, excess zinc may inhibit intestinal copper absorption and thus copper status, subsequently leading to its deficiency. In recognition of this interaction, a ratio of 1 to 2 mg of copper for each 8 to 15 mg of zinc should be maintained (Gletsu-Miller & Wright, 2013; Mechanick et al., 2013).
**Table 1**

Postoperative Vitamin Supplementation Recommendations by Surgery Type, LRYGB vs. LSG

<table>
<thead>
<tr>
<th>Supplement</th>
<th>LRYGB</th>
<th>LSG</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVI containing iron, folic acid, thiamin, and zinc</td>
<td>200% DV of at least 2/3 of nutrients; 2 tablets daily</td>
<td>200% DV of at least 2/3 of nutrients; 2 tablets daily</td>
</tr>
<tr>
<td>Vitamin B1 (Thiamin)</td>
<td>Acute: 100 mg/day x 7-14 days (IM) then 10 mg/day (oral)</td>
<td>Acute: 100 mg/day x 7-14 days (IM) then 10 mg/day (oral)</td>
</tr>
<tr>
<td>Vitamin B12 (sublingual)</td>
<td>1,000 mcg/day</td>
<td>500 mcg/day</td>
</tr>
<tr>
<td>Folate</td>
<td>800 mcg/day</td>
<td>400 mcg/day</td>
</tr>
<tr>
<td>Elemental Iron</td>
<td>150-200 mg elemental iron, including amount taken in MVI</td>
<td>325 mg elemental iron, including amount taken in MVI</td>
</tr>
<tr>
<td>Calcium Citrate with Vitamin D</td>
<td>1,500-2,000 mg of calcium citrate and 800 IU vitamin D3 daily</td>
<td>1,200-1,500 mg of calcium citrate and 400-800 IU vitamin D3 daily</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>5,000-10,000 IU/day</td>
<td>5,000-10,000 IU/day</td>
</tr>
<tr>
<td>Zinc</td>
<td>8-15 mg</td>
<td>8-15 mg</td>
</tr>
<tr>
<td>Copper</td>
<td>Oral (1-2mg/day) or IV fusion, response variable</td>
<td>Oral (1-2mg/day) or IV fusion, response variable</td>
</tr>
</tbody>
</table>

*Note.* Retrieved from Aills et al., 2008; Mechanick et al., 2013; Snyder-Marlow et al., 2010.

MVI = Multivitamin; DV = Daily Value; IM = Intramuscular Injection; IU = International Unit

**Postoperative follow-up.** Patients who have undergone bariatric surgery require long-term, regular follow-up care by the bariatric team, including the surgeon, the obesity specialist, the endocrinologist, the bariatric dietitian, and mental health professionals (Aills et al., 2008; Kulick et al., 2010; Mechanick et al., 2013; Tempest, 2012). Follow-
up visits are scheduled at one, three, six, and 12 months, and annually thereafter, unless otherwise indicated (Kulick et al., 2010; Fujioka, 2005; Mechanick et al., 2013).

Bariatric dietitians who care for patients after bariatric surgery need to identify red flags, triage nutritional deficiencies, and be familiar with common postoperative symptoms related to the surgical risks (e.g., gastric leak; gastric ulcer; gastric stricture) (Craggs-Dino, 2014; Furtado, 2012). Typical postoperative follow-up care involves reassessment of anthropometric data, laboratory parameters, dietary compliance and adherence with prescribed multivitamin-mineral protocol, and medication review (Aills et al., 2008). Postoperative follow-up can also address patient concerns and challenges, help troubleshoot dumping syndrome, reestablish and help maintain dietary goals and prevent weight regain, and offer strategies to continue postoperative care at home (Kulick et al., 2010; McMahon et al., 2006).
CHAPTER III

METHODOLOGY

Study Design and Sample

A descriptive survey on protocol availability for perioperative nutritional care and current perioperative nutritional care practices for patients undergoing bariatric surgery in MBSAQIP-accredited centers was performed between December 2016 and February 2017. MBSAQIP-accredited centers were identified using the 2016 American College of Surgeons directory. The directory was accessed on the American College of Surgeons website at: https://www.facs.org/search/bariatric-surgery-centers. Additional MBSAQIP-accredited centers were obtained through Optum’s TM Bariatric Centers of Excellence Network. Medical directors and program coordinators whose electronic mail address or fax number were listed on the hospital website were contacted mid-November 2016. In the first instance, the medical director and program coordinator of each selected hospital were contacted for permission to carry out the study and to ascertain the contact information of dietitians in their bariatric surgery program at their institution and all affiliated facilities/locations. The letter (Appendix A) consisted of an explanation of the and its purpose, with the contact information of both the principle investigator and co-investigator. Bariatric dietitians whose electronic mail address was listed in the Academy of Nutrition and Dietetics online referral service database were also used to solicit participation.
Survey Development

The survey was developed based on a review of the literature. The final survey was 96 items (Appendix E). The first part of the survey ascertained the demographic characteristics of the respondent and facility using multiple-choice, closed, and free text-box questions. The second part of the survey queried about the availability of perioperative nutritional care protocols using closed questions. A list of possible components that might be included in perioperative nutritional care protocols was created. The third part of the survey established respondents current perioperative nutritional care practices. Each item was measured on a five-point Likert scale ranging from 1=Never, through 2=Rarely, 3=Sometimes, 4=Often, and 5=Always. Participants rated their importance of a standardized process or protocol for perioperative nutritional care on a five-point scale ranging from 1=Not at all Important, through 2=Slightly Important, 3=Moderately Important, 4=Very Important, and 5=Extremely Important. Participants rated their level of agreement of statements relating to facility-based perioperative nutritional management practices and knowledge of surgical techniques on a five-point scale ranging from 1=Strongly Disagree, through 2=Disagree, 3=Neutral, 4=Agree, and 5=Strongly Agree.

Procedures

The survey was administered by electronic mail via a standardized internet survey application (Qualtrics®, United States). All bariatric dietitians were invited to complete the 20-25 minute internet-based survey via email invitation (Appendix B) with a link to the Qualtrics® platform. Reminder emails (Appendix C) were issued to non-responders at
intervals of two weeks for a total of eight weeks. No remuneration or incentives were offered for participating in the survey. Anonymity and confidentiality were assured to all respondents who completed the survey. Respondents’ informed consent (Appendix D) was taken prior to completing the survey. The study was approved by the Institutional Review Board at Kent State University (Approval Number: No. 16-751).

**Statistical Analysis**

Data analysis was carried out using Statistical Package for the Social Sciences (SPSS) Version 24.0 software. Categorical variables were summarized with frequencies and percentages; continuous variables were summarized with means and standard deviations. Subscale scores were introduced as continuous variables. Five-point Likert scales were collapsed to three categories for analysis; subscales 1 and 2 were collapsed into one category and subscales 4 and 5 were collapsed into one category, yielding a three-point Likert scale. Mean and standard deviation calculations were run based on the five-point Likert scale.
CHAPTER IV

RESULTS

Demographic Characteristics of Surveyed Respondents

Surveys were distributed amongst 93 practicing registered and licensed bariatric dietitians across the United States. Overall, 48 bariatric dietitians responded, giving a response rate of 52%. Table 2 presents the demographic characteristics of the study sample. Respondents were predominantly female (93.6%) with a mean age of 36.3 years (range: 24-65). The largest subset of respondents was from the Northeast (44.4%). For the highest degree earned, 46.8% (n=22) of the participants reported holding Bachelor’s degrees and 53.2% (n=25) held Master’s degrees. The respondents had on average been Commission on Dietetic Registration (CDR) board-certified for 10.97±9.67 years, and specializing in bariatrics an average of 5.91±4.74 years. Eighty-three percent (n=39) identified their current role as outpatient bariatric dietitian, while 17% identified as both inpatient and outpatient bariatric dietitian. When asked for the number of patients seen, nearly 60% of respondents attend between 1 and 100 patients per month.
Table 2

*Demographic Characteristics of Bariatric Dietitian Survey Respondents (n=47)*

<table>
<thead>
<tr>
<th>Gender</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>1</td>
<td>2.1</td>
</tr>
<tr>
<td>Female</td>
<td>44</td>
<td>93.6</td>
</tr>
<tr>
<td>Additional Category</td>
<td>1</td>
<td>2.1</td>
</tr>
<tr>
<td>Decline to State</td>
<td>1</td>
<td>2.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Region</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast</td>
<td>20</td>
<td>44.4</td>
</tr>
<tr>
<td>Midwest</td>
<td>9</td>
<td>20.0</td>
</tr>
<tr>
<td>South</td>
<td>10</td>
<td>22.2</td>
</tr>
<tr>
<td>West</td>
<td>6</td>
<td>13.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Education – Highest Level Obtained</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelor degree</td>
<td>22</td>
<td>46.8</td>
</tr>
<tr>
<td>Master degree</td>
<td>25</td>
<td>53.2</td>
</tr>
<tr>
<td>Doctorate</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Profession</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inpatient</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Outpatient</td>
<td>39</td>
<td>83.0</td>
</tr>
<tr>
<td>Both</td>
<td>8</td>
<td>17.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Patients Seen Per Month</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1</td>
<td>1</td>
<td>2.1</td>
</tr>
<tr>
<td>1-100</td>
<td>28</td>
<td>59.6</td>
</tr>
<tr>
<td>101-200</td>
<td>13</td>
<td>27.7</td>
</tr>
<tr>
<td>201-300</td>
<td>4</td>
<td>8.5</td>
</tr>
<tr>
<td>301-400</td>
<td>1</td>
<td>2.1</td>
</tr>
<tr>
<td>&gt;400</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Illinois, Michigan, Missouri, Ohio, Wisconsin.  
Florida, South Carolina, Tennessee, Texas, Virginia.  
Arizona, California, Nevada, Oregon*

**Characteristics of Accredited Centers of Surveyed Respondents**

Institutional characteristics of survey respondents are summarized in Table 3.

Almost half of bariatric dietitians (48.9%) reported practicing in outpatient clinic settings.

Nearly all participants (97.9%) reported that laparoscopy was most commonly utilized for
bariatric surgical procedures. Vertical sleeve gastrectomy was reported as the most often seen surgery (68.1%). Most institutions (85.1%) have designated inpatient surgical units for postoperative bariatric patients. One-third of participants (32.4%) reported only eight- to 10 beds per unit, while less than half (44.1%) reported less than seven per unit.
Table 3

*Characteristics of MBSAQIP-Accredited Centers of Surveyed Bariatric Dietitians (n=47)*

<table>
<thead>
<tr>
<th>Procedure Seen Most Often</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjustable Gastric Banding</td>
<td>1</td>
<td>2.1</td>
</tr>
<tr>
<td>Roux-en-Y Gastric Bypass</td>
<td>14</td>
<td>29.8</td>
</tr>
<tr>
<td>Vertical Sleeve Gastrectomy</td>
<td>32</td>
<td>68.1</td>
</tr>
<tr>
<td>Biliopancreatic Bypass with or without Duodenal Switch</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Revisions</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Practice Setting</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community Hospital</td>
<td>10</td>
<td>21.3</td>
</tr>
<tr>
<td>Teaching/Academic Medical Center</td>
<td>8</td>
<td>17.0</td>
</tr>
<tr>
<td>Specialized Hospital</td>
<td>3</td>
<td>6.4</td>
</tr>
<tr>
<td>Outpatient Clinic</td>
<td>23</td>
<td>48.9</td>
</tr>
<tr>
<td>Other(^a)</td>
<td>3</td>
<td>6.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Designated Bariatric Inpatient Unit</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>40</td>
<td>85.1</td>
</tr>
<tr>
<td>No</td>
<td>7</td>
<td>14.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Beds Per Bariatric Unit</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 7</td>
<td>15</td>
<td>44.1</td>
</tr>
<tr>
<td>8-10</td>
<td>11</td>
<td>32.4</td>
</tr>
<tr>
<td>11-15</td>
<td>2</td>
<td>5.9</td>
</tr>
<tr>
<td>16-20</td>
<td>3</td>
<td>8.8</td>
</tr>
<tr>
<td>21-30</td>
<td>3</td>
<td>8.8</td>
</tr>
<tr>
<td>31-40</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>&gt; 40</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Annual Volume of Bariatric Surgery Procedures</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 50 Cases</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>51-100 Cases</td>
<td>2</td>
<td>4.3</td>
</tr>
<tr>
<td>101-150 Cases</td>
<td>9</td>
<td>19.1</td>
</tr>
<tr>
<td>151-200 Cases</td>
<td>9</td>
<td>19.1</td>
</tr>
<tr>
<td>201-300 Cases</td>
<td>7</td>
<td>14.9</td>
</tr>
<tr>
<td>&gt; 300 Cases</td>
<td>14</td>
<td>29.8</td>
</tr>
<tr>
<td>Don’t know/Unsure</td>
<td>6</td>
<td>12.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bariatric Surgical Technique Utilized</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Surgery</td>
<td>1</td>
<td>2.1</td>
</tr>
<tr>
<td>Laparoscopy</td>
<td>46</td>
<td>97.9</td>
</tr>
</tbody>
</table>

\(^a\) Other practice settings indicated: Doctor Office; Private Surgeon’s Office
Self-Perceived Importance of Standardization of Perioperative Nutritional Management Among Bariatric Dietitians

Bariatric dietitians’ views were sought regarding their perceived importance of a standardized process or protocol for perioperative nutritional management. Responses were measured on a five-point Likert scale ranging from 1=Not at all Important to 5=Extremely Important. The majority of surveyed respondents (94.2%, n=33 out of 35) felt that a standardized process or protocol for the perioperative nutritional management of the bariatric surgical patient was either “very important or extremely important”.

Bariatric Dietitians’ Attitudes Towards Facility-Based Perioperative Nutrition Management Practices

Bariatric dietitians were asked to rate their level of agreement or disagreement (on a five-point Likert scale from 1=Strongly Disagree to 5=Strongly Agree) with the following statement: “The current perioperative nutritional management of patients undergoing bariatric surgery at my institution could be improved.” Overall, surveyed respondents offered contrasting attitudes towards their institution’s current perioperative management practices: about half (45.7%, n=16 out of 35) “agreed or strongly agreed” that existing management practices could be improved, while over one-third (37.1%, n=13 out of 35) “disagreed or strongly disagreed”; a minority (17.1%, n=6 out of 35) remained “neutral” to the statement.

Self-Reported Knowledge of Bariatric Surgical Procedures Among Bariatric Dietitians

Bariatric dietitians were asked to rate their level of agreement or disagreement (on a five-point Likert scale from 1=Strongly Disagree to 5=Strongly Agree) with the following statement: “I have enough knowledge about each of the current popular
surgical procedures (AGB, RYGB, VSG, BPD, BPD/DS) to provide safe and appropriate nutrition care for patients.” Overall, the majority of surveyed respondents (91.4%, n=33 out of 35) “agreed or strongly agreed” they had enough knowledge of each bariatric surgical procedure to provide safe and appropriate nutrition care for patients.

**Reported Availability of Protocols for Perioperative Nutritional Care in Accredited Centers**

Bariatric dietitians reported availability of protocols for perioperative nutritional management is summarized in Table 4. The majority of surveyed participants (91.5%) reported the presence of a written protocol for preoperative nutritional management, and the majority (91.5%) confirmed availability for postoperative nutritional management. One-quarter of respondents (23.4%) acknowledged the availability of protocols on managing a specific subpopulation of bariatric patients with complex medical conditions, one-third (34%) stated that they had no protocol available, and less than half (42.6%) were unsure as to whether such a document existed in their institution. Over half (54.3%, n=25 out of 46) reported availability of a written protocol for documentation of patient adherence to prescribed postoperative nutritional regimen, and less than half (43.5%, n=20 out of 46) had no protocol available (data not shown).
Table 4

*Availability of Protocols for Perioperative Nutritional Care in MBSAQIP-Accredited Centers as Reported by the Surveyed Bariatric Dietitians (n=47)*

<table>
<thead>
<tr>
<th>Type of Protocol</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative Nutritional Care</td>
<td>43</td>
<td>91.5</td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>2</td>
<td>4.3</td>
</tr>
<tr>
<td>Don’t know/Unsure</td>
<td>2</td>
<td>4.3</td>
</tr>
<tr>
<td>Postoperative Nutritional Care</td>
<td>43</td>
<td>91.5</td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1</td>
<td>2.1</td>
</tr>
<tr>
<td>Don’t know/Unsure</td>
<td>3</td>
<td>6.4</td>
</tr>
<tr>
<td>Perioperative Nutritional Care for Specific-Patient Subpopulations</td>
<td>11</td>
<td>23.4</td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>16</td>
<td>34.0</td>
</tr>
<tr>
<td>Don’t know/Unsure</td>
<td>20</td>
<td>42.6</td>
</tr>
</tbody>
</table>

**Perioperative nutritional care components.** Table 5 summarizes additional components of these protocols, specifically concerning the care of patients before and after surgery, and a specific subpopulation of bariatric patients with complex medical conditions. For preoperative nutrition care protocols, most (60.5%) maintained content for appropriate referral processes and procedures, but far fewer of the institutions queried used standard protocols for weight loss and criteria (48.8%), liquid diet regimens (39.5%), very low-calorie and low-calorie diet regimens (32.6%), and glycemic control (32.6%). One-quarter of protocols (25.6%) reportedly included “other” content.

Programs with postoperative nutrition care protocols most commonly included nutrition recommendations during the immediate postoperative period (95.3%), followed by postoperative meal initiation and progression (88.4%), specific surgery-related dietary recommendations (76.7%), and management of postoperative dietary complications (74.4%). Less than half of postoperative nutrition care protocols maintained content for
measurement of clinical observations in the immediate postoperative period (48.8%), referral processes and procedures (46.5%), weight regain prevention and treatment (44.2%), relapse management (34.9%), glycemic control (27.9%), and enteral and parenteral feeding/nutrition (11.6%). In the “other” response, one respondent commented that their postoperative nutrition care protocol contains vitamin recommendations.

Concerning perioperative nutrition care protocols for patient-specific subpopulations, the majority of these documents (72.7%) targeted patients with type 2 diabetes mellitus; the remainder applied to patients with type 1 diabetes mellitus (45.5%), requiring renal dialysis (45.5%), and receiving mechanical ventilation (18.2%).
Table 5

*Reported Components of Perioperative Nutritional Care Protocols as Reported by the Surveyed Bariatric Dietitians*

<table>
<thead>
<tr>
<th>Preoperative Nutritional Care (n=43)</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>VLCD or LCD regimen</td>
<td>14</td>
<td>32.6</td>
</tr>
<tr>
<td>Liquid diet regimen</td>
<td>17</td>
<td>39.5</td>
</tr>
<tr>
<td>Weight loss requirements/criteria</td>
<td>21</td>
<td>48.8</td>
</tr>
<tr>
<td>Glycemic control</td>
<td>14</td>
<td>32.6</td>
</tr>
<tr>
<td>Referral processes and procedures</td>
<td>26</td>
<td>60.5</td>
</tr>
<tr>
<td>Don’t know/Unsure</td>
<td>1</td>
<td>2.3</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>25.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Postoperative Nutritional Care (n=43)</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management of postoperative dietary complications</td>
<td>32</td>
<td>74.4</td>
</tr>
<tr>
<td>Measurement of clinical observations in the immediate postoperative period</td>
<td>21</td>
<td>48.8</td>
</tr>
<tr>
<td>Nutrition recommendations during the immediate postoperative period</td>
<td>41</td>
<td>95.3</td>
</tr>
<tr>
<td>Specific surgery-related dietary recommendations</td>
<td>33</td>
<td>76.7</td>
</tr>
<tr>
<td>Postoperative meal initiation and progression</td>
<td>38</td>
<td>88.4</td>
</tr>
<tr>
<td>Glycemic control</td>
<td>12</td>
<td>27.9</td>
</tr>
<tr>
<td>Referral processes and procedures</td>
<td>20</td>
<td>46.5</td>
</tr>
<tr>
<td>Enteral and parenteral feeding/nutrition</td>
<td>5</td>
<td>11.6</td>
</tr>
<tr>
<td>Weight regain prevention and treatment</td>
<td>19</td>
<td>44.2</td>
</tr>
<tr>
<td>Relapse management (prevention/maintenance)</td>
<td>15</td>
<td>34.9</td>
</tr>
<tr>
<td>Don’t know/Unsure</td>
<td>3</td>
<td>6.9</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>4.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Perioperative Patient-Specific Nutritional Care (n=11)</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1 diabetes mellitus</td>
<td>5</td>
<td>45.5</td>
</tr>
<tr>
<td>Type 2 diabetes mellitus</td>
<td>8</td>
<td>72.7</td>
</tr>
<tr>
<td>On dialysis before surgery</td>
<td>3</td>
<td>27.3</td>
</tr>
<tr>
<td>Remaining on dialysis after surgery</td>
<td>2</td>
<td>18.2</td>
</tr>
<tr>
<td>Receiving mechanical ventilation</td>
<td>2</td>
<td>18.2</td>
</tr>
<tr>
<td>Don’t know/Unsure</td>
<td>2</td>
<td>18.2</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

*Note.* Percentages add up to more than 100% as more than one component could be selected per protocol. a, b, and c do not total corresponding “n” total because more than one component could be selected per protocol. VLDC = Very-low calorie diet; LCD = Low-calorie diet
Table 6 summarizes the perioperative nutrition risk screening practices among multidisciplines and surveyed respondents in accredited centers. Routine multidisciplinary nutritional screening before and after surgery were common practices at most sites; majority of surveyed bariatric dietitians (84.8%) reported that nutritional screening is “always or often” followed routinely before surgery (4.52±1.01), and over three-fourths (82.2%) followed screening procedures after surgery (4.31±1.01). Triage of high-nutrition risk surgical patients before and after surgery received the lowest scores (3.69±1.41 and 3.55±1.44, respectively).
Table 6

*Perioperative Nutrition Risk Screening Practices Among Multidisciplines and Surveyed Bariatric Dietitians in MBSAQIP-Accredited Centers*

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mean±SDa</th>
<th>Rarely/Never n (%)</th>
<th>Sometimes n (%)</th>
<th>Always/Often n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multidisciplinary nutrition screening is followed routinely before surgery. (n=46)</td>
<td>4.52±1.01</td>
<td>2 (4.3)</td>
<td>5 (10.9)</td>
<td>39 (84.8)</td>
</tr>
<tr>
<td>Multidisciplinary nutrition screening is followed routinely after surgery. (n=46)</td>
<td>4.31±1.06</td>
<td>3 (6.7)</td>
<td>5 (11.1)</td>
<td>37 (82.2)</td>
</tr>
<tr>
<td>I triage nutritional risk in sufficient time to correct subclinical deficiency before surgery. (n=45)</td>
<td>3.69±1.41</td>
<td>11 (24.4)</td>
<td>8 (17.8)</td>
<td>26 (57.8)</td>
</tr>
<tr>
<td>I triage post-bariatric patients for malnutrition diagnosis. (n=44)</td>
<td>3.55±1.44</td>
<td>12 (27.3)</td>
<td>8 (18.2)</td>
<td>24 (54.5)</td>
</tr>
</tbody>
</table>

a Scores run based on 5-point Likert scale where (1) denoted “Never” and (5) “Always”. SD = Standard Deviation

**Self-Reported Perioperative Nutrition Assessment Practices Among Bariatric Dietitians**

Table 7 presents the means, standard deviations, and frequencies for surveyed bariatric dietitians self-reported perioperative nutrition assessment practices. Nutritional assessment for determining contraindications and suitability before starting the preoperative diet protocol received the highest score (4.47±1.12); nutritional assessment
for determining potential disordered eating in surgical candidates, the lowest

$(4.22 \pm 1.22)$.  

Table 7

*Self-Reported Perioperative Nutrition Assessment Practices Among Surveyed Bariatric Dietitians*

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mean±SD$^a$</th>
<th>Rarely/Never n (%)</th>
<th>Sometimes n (%)</th>
<th>Always/Often n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I complete a history and physical. (n=45)</td>
<td>4.42±1.12</td>
<td>4 (8.9)</td>
<td>4 (8.9)</td>
<td>37 (82.2)</td>
</tr>
<tr>
<td>I assess for potential disordered eating in surgery candidates. (n=45)</td>
<td>4.22±1.22</td>
<td>6 (13.3)</td>
<td>5 (11.1)</td>
<td>34 (75.6)</td>
</tr>
<tr>
<td>I assess for contraindications and suitability before starting preoperative diet protocol. (n=45)</td>
<td>4.47±1.12</td>
<td>3 (6.7)</td>
<td>4 (8.9)</td>
<td>38 (84.4)</td>
</tr>
<tr>
<td>Nutrition assessments and reassessments are documented within the timeframes defined in the clinical nutrition policies. (n=45)</td>
<td>4.44±1.12</td>
<td>3 (6.7)</td>
<td>4 (8.9)</td>
<td>38 (84.4)</td>
</tr>
<tr>
<td>Nutrition reassessments address the status of the previous nutrition problems and progress towards goals. (n=44)</td>
<td>4.39±1.04</td>
<td>2 (4.5)</td>
<td>6 (13.6)</td>
<td>36 (81.8)</td>
</tr>
</tbody>
</table>

$^a$Scores run based on 5-point Likert scale where (1) denoted “Never” and (5) “Always”. SD = Standard Deviation
Self-Reported Preoperative Nutritional Strategies Used by Bariatric Dietitians to Prepare Candidates for Bariatric Surgery

Table 8 presents the means, standard deviations, and frequencies for surveyed bariatric dietitians self-reported preoperative nutritional strategies they use to prepare candidates for bariatric surgery. Strategies for both postoperative nutrient and daily fluid intake and dietary behavior change received the highest scores (5.00±0.00); recommendations on fiber supplementation, the lowest (3.67±1.11).
### Table 8

**Self-Reported Preoperative Nutritional Strategies Used by the Surveyed Bariatric Dietitians to Prepare Candidates for Bariatric Surgery**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mean±SD[^a^]</th>
<th>Rarely/Never n (%)</th>
<th>Sometimes n (%)</th>
<th>Always/Often n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I tailor dietary change to food preferences and allow for individual approach. (n=43)</td>
<td>4.70±0.60</td>
<td>0 (0.0)</td>
<td>3 (7.0)</td>
<td>40 (93.0)</td>
</tr>
<tr>
<td>I provide instruction of postoperative nutrient and daily fluid intake recommendations. (n=43)</td>
<td>5.00±0.00</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>43 (100.0)</td>
</tr>
<tr>
<td>I advise about very low-calorie diet product selection. (n=41)</td>
<td>3.95±1.22</td>
<td>5 (12.2)</td>
<td>10 (24.4)</td>
<td>26 (63.4)</td>
</tr>
<tr>
<td>I advise about protein supplements. (n=43)</td>
<td>4.91±0.48</td>
<td>1 (2.3)</td>
<td>0 (0.0)</td>
<td>42 (97.7)</td>
</tr>
<tr>
<td>I advise about low carbohydrate-low calorie foods. (n=42)</td>
<td>4.74±0.54</td>
<td>0 (0.0)</td>
<td>2 (4.8)</td>
<td>40 (95.2)</td>
</tr>
<tr>
<td>I advise about fiber supplementation. (n=43)</td>
<td>3.67±1.11</td>
<td>4 (9.3)</td>
<td>17 (39.5)</td>
<td>22 (51.2)</td>
</tr>
<tr>
<td>I advise about adequate hydration. (n=43)</td>
<td>4.91±0.37</td>
<td>0 (0.0)</td>
<td>1 (2.3)</td>
<td>42 (97.7)</td>
</tr>
<tr>
<td>I discuss the importance of supplementation compliance. (n=43)</td>
<td>4.88±0.39</td>
<td>0 (0.0)</td>
<td>1 (2.3)</td>
<td>42 (97.7)</td>
</tr>
<tr>
<td>I discuss specific surgery-related recommendations. (n=43)</td>
<td>4.91±0.43</td>
<td>0 (0.0)</td>
<td>2 (4.7)</td>
<td>41 (95.3)</td>
</tr>
<tr>
<td>I review dietary guidelines with the patient before surgery. (n=43)</td>
<td>4.93±0.34</td>
<td>0 (0.0)</td>
<td>1 (2.3)</td>
<td>42 (97.7)</td>
</tr>
<tr>
<td>I discuss techniques and tips to maximize food and fluid tolerance. (n=43)</td>
<td>4.88±0.32</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>43 (100.0)</td>
</tr>
<tr>
<td>I advise about surgeon-specific requirements. (n=43)</td>
<td>4.33±1.36</td>
<td>5 (11.6)</td>
<td>4 (9.3)</td>
<td>34 (79.1)</td>
</tr>
<tr>
<td>I provide recommendations on dietary behavior change. (n=43)</td>
<td>5.00±0.00</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>43 (100.0)</td>
</tr>
</tbody>
</table>

[^a^] Scores run based on 5-point Likert scale where (1) denoted “Never” and (5) “Always”. SD = Standard Deviation
Preoperative Patient Education Practices in Accredited Centers and Among Bariatric Dietitians

Table 9 presents the means, standards deviations, and frequencies of accredited centers perioperative patient education practices as reported by survey participants. Of these, the item “Instructions regarding diet, exercise vitamin/mineral supplementation (dose, timing, precautions), and lifestyle changes are communicated with and given to patients undergoing bariatric surgery” was the highest (4.95±0.32). The item “For readmission, patient education and discharge planning is emphasized on a daily basis” (4.50±0.96).
Table 9
Preoperative Patient Education Practices in MBSAQIP-Accredited Centers and Among Surveyed Bariatric Dietitians

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mean±SD</th>
<th>Rarely/Never n (%)</th>
<th>Sometimes n (%)</th>
<th>Always/Often n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient education materials are current and consistent with the bariatric diet guidelines. (n=41)</td>
<td>4.66±0.58</td>
<td>0 (0.0)</td>
<td>2 (4.9)</td>
<td>39 (95.1)</td>
</tr>
<tr>
<td>Patients receive quality nutrition education specific to assessed needs, abilities, learning preferences, and readiness to learn. (n=41)</td>
<td>4.66±0.53</td>
<td>0 (0.0)</td>
<td>1 (2.4)</td>
<td>40 (97.6)</td>
</tr>
<tr>
<td>Patients receive education in a protocol-derived staged meal progression based on their surgical procedure. (n=41)</td>
<td>4.90±0.37</td>
<td>0 (0.0)</td>
<td>1 (2.4)</td>
<td>40 (97.6)</td>
</tr>
<tr>
<td>Guidelines for long-term weight loss and maintenance are reviewed before bariatric surgery. (n=41)</td>
<td>4.76±0.73</td>
<td>1 (2.4)</td>
<td>1 (2.4)</td>
<td>39 (95.1)</td>
</tr>
<tr>
<td>Guidelines for long-term weight loss and maintenance are reviewed after bariatric surgery. (n=41)</td>
<td>4.71±0.64</td>
<td>0 (0.0)</td>
<td>4 (9.8)</td>
<td>37 (90.2)</td>
</tr>
<tr>
<td>Dietetic support encompasses the provision of dietary advice appropriate to the procedures (and outcomes). (n=41)</td>
<td>4.90±0.37</td>
<td>0 (0.0)</td>
<td>1 (2.4)</td>
<td>40 (97.6)</td>
</tr>
<tr>
<td>Preoperative education addresses the expected course of the perioperative nutritional care. (n=41)</td>
<td>4.88±0.40</td>
<td>0 (0.0)</td>
<td>1 (2.4)</td>
<td>40 (97.6)</td>
</tr>
<tr>
<td>Preoperative education addresses indications and contraindications for bariatric surgery. (n=40)</td>
<td>4.70±0.85</td>
<td>2 (5.0)</td>
<td>1 (2.5)</td>
<td>37 (92.5)</td>
</tr>
<tr>
<td>Instructions are communicated with and given to patients undergoing bariatric surgery. (n=40)</td>
<td>4.95±0.32</td>
<td>0 (0.0)</td>
<td>1 (2.1)</td>
<td>39 (97.5)</td>
</tr>
<tr>
<td>Education provided to inpatients is documented in the medical record. (n=37)</td>
<td>4.68±0.97</td>
<td>2 (5.4)</td>
<td>1 (2.7)</td>
<td>34 (91.9)</td>
</tr>
<tr>
<td>When outpatient education is provided, the dietitian documents the teaching methods used, the patient’s understanding, compliance issues, if present, and follow-up plans. (n=40)</td>
<td>4.58±0.96</td>
<td>2 (5.0)</td>
<td>4 (10.0)</td>
<td>34 (85.0)</td>
</tr>
<tr>
<td>Education goals are communicated to the surgical team. (n=59)</td>
<td>4.64±0.74</td>
<td>1 (2.6)</td>
<td>3 (7.7)</td>
<td>35 (89.7)</td>
</tr>
<tr>
<td>Bariatric staff have adequate educational resources regarding dietary guidelines, meal progression, supplementation, etc. (n=40)</td>
<td>4.78±0.58</td>
<td>0 (0.0)</td>
<td>3 (7.5)</td>
<td>37 (92.5)</td>
</tr>
<tr>
<td>For readmission, patient education and discharge planning is emphasized on a daily basis. (n=34)</td>
<td>4.50±0.96</td>
<td>1 (2.9)</td>
<td>5 (14.7)</td>
<td>28 (82.4)</td>
</tr>
</tbody>
</table>

*Scores run based on 5-point Likert scale where (1) denoted “Never” and (5) “Always”. SD = Standard Deviation
### Diet Instructions Introduced to Patients Before Discharge by Bariatric Dietitians

Table 10 presents the means, standard deviations, and frequencies of self-reported diet instructions introduced to patients before hospital discharge by surveyed bariatric dietitians. Of these, the item “Dietary discharge instructions are communicated with patients after surgery” was the highest (4.94±0.69). The item “Discharge instructions incorporate activity/exercise instructions” rated the lowest (4.56±1.05).

#### Table 10

*Diet Instructions Introduced to Patients Before Hospital Discharge as Reported by the Surveyed Bariatric Dietitians*

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mean±SD</th>
<th>Rarely/Never n (%)</th>
<th>Sometimes n (%)</th>
<th>Always/Often n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDIs are communicated with patients after surgery. (n=37)</td>
<td>4.94±0.69</td>
<td>1 (2.7)</td>
<td>0 (0.0)</td>
<td>36 (97.3)</td>
</tr>
<tr>
<td>Written DDI’s are provided to patients after surgery. (n=37)</td>
<td>4.57±1.09</td>
<td>3 (8.1)</td>
<td>2 (5.4)</td>
<td>32 (86.5)</td>
</tr>
<tr>
<td>DDIs incorporate medication and nutritional supplementation guidance. (n=35)</td>
<td>4.69±0.99</td>
<td>2 (5.7)</td>
<td>1 (2.9)</td>
<td>32 (91.4)</td>
</tr>
<tr>
<td>DDIs incorporate activity/exercise instructions. (n=35)</td>
<td>4.56±1.05</td>
<td>2 (5.9)</td>
<td>2 (5.9)</td>
<td>30 (88.2)</td>
</tr>
<tr>
<td>DDIs incorporate follow-up/referrals. (n=35)</td>
<td>4.80±0.76</td>
<td>1 (2.9)</td>
<td>1 (2.9)</td>
<td>33 (94.3)</td>
</tr>
</tbody>
</table>

*a* Scores run based on 5-point Likert scale where (1) denoted “Never” and (5) “Always”. SD = Standard Deviation; DDIs = Dietary Discharge Instructions
Self-Reported Postoperative Nutritional Monitoring Practices Among Bariatric Dietitians

Table 11 presents the means, standard deviations, and frequencies for surveyed bariatric dietitians self-reported postoperative nutritional monitoring practices. Recommendations for addressing and monitoring adherence to supplementation regimen, and reinforcing dietary behavior strategies showed the highest rates (4.90±0.30 and 4.90±0.37, respectively), whereas recommendations for assessing and monitoring food texture compliance received the lowest rates (4.67±0.65).

Table 11

Self-Reported Postoperative Nutritional Monitoring Practices Among Surveyed Bariatric Dietitians (n=42)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mean±SDa</th>
<th>Rarely/Never n (%)</th>
<th>Sometimes n (%)</th>
<th>Always/Often n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I address and monitor adequacy of diet.</td>
<td>4.86±0.42</td>
<td>0 (0.0)</td>
<td>1 (2.4)</td>
<td>41 (97.6)</td>
</tr>
<tr>
<td>I address and monitor adherence to supplementation regimen.</td>
<td>4.90±0.30</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>42 (100.0)</td>
</tr>
<tr>
<td>I address and monitor food intolerance issues.</td>
<td>4.81±0.51</td>
<td>0 (0.0)</td>
<td>2 (4.8)</td>
<td>40 (95.2)</td>
</tr>
<tr>
<td>I assess and monitor food texture compliance.</td>
<td>4.67±0.65</td>
<td>0 (0.0)</td>
<td>4 (9.5)</td>
<td>38 (90.5)</td>
</tr>
<tr>
<td>I reinforce dietary behavior strategies.</td>
<td>4.90±0.37</td>
<td>0 (0.0)</td>
<td>1 (2.4)</td>
<td>41 (97.6)</td>
</tr>
</tbody>
</table>

aScores run based on 5-point Likert scale where (1) denoted “Never” and (5) “Always”. SD = Standard Deviation
Multidisciplinary Team Approach in Bariatric Surgery

Multidisciplinary team-based approach is recommended for management of bariatric surgery patients. The multidisciplinary bariatric surgery team consists of surgeons, anesthesiologist, nurses, psychologists, dietitians, and medical subspecialties as clinically indicated.

**Health care provider involvement in postoperative patient education.**

Bariatric dietitian and surgeon involvement in postoperative patient education about dietary guidelines, the progression of diet stages, and supplementation was present in most of the practices (Table 12); nearly all (97.5%) had bariatric dietitians “always or often” provide education (4.93±0.35) and two-thirds (67.5%) “always or often” had surgeon involvement (4.10±0.93).
Table 12

Involvement of Health Care Provider in the Postoperative Education of Dietary Guidelines, Meal Progression, Multivitamin-Mineral Supplementation Regimen as Reported by the Surveyed Bariatric Dietitians

<table>
<thead>
<tr>
<th>Health Care Provider</th>
<th>Mean±SDa</th>
<th>Rarely/Never n (%)</th>
<th>Sometimes n (%)</th>
<th>Always/Often n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician (MD or DO) (n=35)</td>
<td>2.97±1.22</td>
<td>11 (31.4)</td>
<td>11 (31.4)</td>
<td>13 (37.1)</td>
</tr>
<tr>
<td>Bariatric Surgeon (n=40)</td>
<td>4.10±0.93</td>
<td>1 (2.5)</td>
<td>12 (30.0)</td>
<td>27 (67.5)</td>
</tr>
<tr>
<td>Board-Certified Physician Assistant (n=36)</td>
<td>3.64±1.57</td>
<td>8 (22.2)</td>
<td>4 (11.1)</td>
<td>24 (66.7)</td>
</tr>
<tr>
<td>Nurse Practitioner (n=33)</td>
<td>2.91±1.72</td>
<td>14 (42.4)</td>
<td>4 (12.1)</td>
<td>15 (45.5)</td>
</tr>
<tr>
<td>Surgical Assistant-Certified (n=27)</td>
<td>1.89±1.40</td>
<td>20 (74.1)</td>
<td>3 (11.1)</td>
<td>4 (14.8)</td>
</tr>
<tr>
<td>Registered Nurse (n=34)</td>
<td>3.91±1.38</td>
<td>5 (14.7)</td>
<td>3 (8.8)</td>
<td>26 (76.5)</td>
</tr>
<tr>
<td>Bariatric Dietitian (n=40)</td>
<td>4.93±0.35</td>
<td>0 (0.0)</td>
<td>1 (2.5)</td>
<td>39 (97.5)</td>
</tr>
</tbody>
</table>

a Scores run based on 5-point Likert scale where (1) denoted “Never” and (5) “Always”. SD = Standard Deviation

**Responsible health care provider for preoperative and postoperative laboratory test orders.** The analysis of the survey question asking about the responsible health care provider for preoperative and postoperative laboratory test orders revealed that the delegation of perioperative laboratory order requests is done primarily by the bariatric surgery (Table 13). A minority of participating bariatric dietitians said that they were exclusively responsible for ordering patient labwork in the preoperative (4.2%) and postoperative (6.3%) period.
Table 13

*Responsible Health Care Provider for Preoperative and Postoperative Laboratory Test Orders as Reported by the Surveyed Bariatric Dietitians (n=48)*

<table>
<thead>
<tr>
<th>Health Care Provider</th>
<th>Preoperative n (%)</th>
<th>Postoperative n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician (MD or DO)</td>
<td>10 (20.8)</td>
<td>8 (16.7)</td>
</tr>
<tr>
<td>Bariatric Surgeon</td>
<td>21 (43.8)</td>
<td>25 (52.1)</td>
</tr>
<tr>
<td>Board-Certified Physician Assistant</td>
<td>10 (20.8)</td>
<td>14 (29.2)</td>
</tr>
<tr>
<td>Nurse Practitioner</td>
<td>11 (22.9)</td>
<td>16 (33.3)</td>
</tr>
<tr>
<td>Surgical-Assistant Certified</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Registered Nurse</td>
<td>4 (8.3)</td>
<td>5 (10.4)</td>
</tr>
<tr>
<td>Bariatric Dietitian</td>
<td>2 (4.2)</td>
<td>3 (6.3)</td>
</tr>
<tr>
<td>Other</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
</tr>
</tbody>
</table>

*Note.* Percentages add up to more than 100% as more than one health care provider could be selected per operative period.
CHAPTER V
DISCUSSION

Demographic Characteristics of Surveyed Respondents

A total of 48 bariatric dietitians were surveyed from a sample of ACS/ASMBS-recognized MBSAQIP bariatric surgical centers in the United States to investigate the existence of protocols available for perioperative nutritional care of patients undergoing bariatric surgery in these centers, and determine current perioperative nutritional care practices in patients undergoing bariatric surgery. Many of the participants reported working in the North Eastern United States, with the South, Midwest, and West also represented in the study. In summary, bariatric dietitians from 21 states participated in this study. Half of surveyed dietitians have been specializing in bariatric for no more than five years.

Characteristics of Accredited Centers of Surveyed Respondents

About half of the institutions were outpatient clinics. In this study, vertical sleeve gastrectomy (VSG) was reported as the most often seen surgery (68.1%), suggesting that this is the most common procedure performed for patients undergoing bariatric surgery at these institutions. This finding contrasts with an earlier study by Wical et al. (2010) which showed that bariatric dietitians most often see patients undergoing Roux-en-Y gastric bypass (RYGB) (93.6% vs. 29.8% in the present study). However, this result reflects a well-established trend of greater VSG usage at U.S. hospitals in general (Angrisani et al., 2015; Nguyen et al., 2013; Reames et al., 2014; Spaniolas et al., 2015).
While the RYGB remains the gold standard technique nationally for bariatric surgery, the VSG is a relatively new procedure that has been widely adopted (ASMBS, 2015; Lager et al., 2017; Nguyen et al., 2013; Spaniolas et al., 2015). Reports highlighting increasing popularity of VSG may be attributable to its relative operative simplicity, absence of malabsorption, preservation of the pylorus, maintenance of normal gastrointestinal continuity, avoidance of foreign material, and lower risk profile (Akkary et al., 2008; Ariyasu et al., 2001; Brethauer et al., 2009; Cummings, 2006; Frezza et al., 2009; Gumbs et al., 2007; Langer et al., 2005; Lee et al., 2007; Tan et al., 2010).

Nationwide analysis using the American College of Surgeons National Surgical Quality Improvement Program database (ACS-NSQIP 2010-2013) showed that the proportion of VSG increased over a three-year period, representing 9.6% and 49.4% of all bariatric procedures in 2010 and 2013, respectively (Spaniolas et al., 2015).

**Bariatric Surgical Technique Utilized**

This study reported that laparoscopy, compared to the other bariatric surgical techniques, was primarily utilized for bariatric surgical procedures, which is in accordance with the results of other previous studies (Buchwald et al., 2007; Maggard et al., 2005; Nguyen, 2004; Nguyen et al., 2011; Padwal et al., 2011; Podnos et al., 2003; Salem et al., 2008; Tiwari et al., 2011). A recent meta-analysis of randomized trials comparing laparoscopic surgery against open methods found that laparoscopy yields lower mortality risk, earlier decline in postoperative morbidity, and fewer immediate and late complications (Reoch et al., 2011).
Self-Perceived Importance of Standardization of Perioperative Nutritional Management Among Bariatric Dietitians

In 2016, the American College of Surgeons (ACS) and the American Society for Metabolic and Bariatric Surgery (ASMBS) published the *Resources for Optimal Care of the Metabolic and Bariatric Surgery Patient* for the MBSAQIP with the primary purpose of ensuring that the safest and highest quality of care is delivered to all bariatric surgery patients. Facilities accredited by the MBSAQIP must utilize clinical protocols that facilitate standardization of best-practices in the perioperative care setting. Comprehensive protocols that outline the continuum of care of the bariatric surgery patient are required by all accredited facilities. It is the general position of the MBSAQIP that all health care providers caring for bariatric surgery patients have been educated to pertinent protocols within their area of practice (ACS & ASMBS, 2016). Re-education should occur throughout the year as needed.

The current literature supports the use of standardized protocols in bariatric surgery. Studies demonstrate that standardized management of care protocols maximize consistency, allow reliability and comparability of measurements, minimize complications, increase efficiency of bariatric services, and reduce health care costs (Campillo-Soto et al., 2008; Frutos et al., 2007; Huerta et al., 2001; Ronellenfitsch et al., 2012; Yeats et al., 2005). In the present study, the importance of standardized perioperative nutritional protocols for the management of bariatric surgery patients was well recognized by the majority of surveyed bariatric dietitians. Although recommended guidelines for perioperative nutritional management exist, they are general and lack
standardization (Aills et al., 2008; AND Evidence Analysis Library, 2009; Rickers & McSherry, 2012; SAGES, 2008).

**Bariatric Dietitians’ Attitudes Towards Facility-Based Perioperative Nutrition Management Practices**

Bariatric dietitians reported divergent attitudes toward their institution’s current perioperative nutrition management practices. With nearly half of respondents expressing general agreement with the statement “The current perioperative nutritional management of patients undergoing bariatric surgery at my institution could be improved,” there is an opportunity for future quality improvement initiatives. It was not ascertained “how” current perioperative nutrition management practices could be improved. On the whole, those bariatric dietitians would have to focus on deficiencies in perioperative nutrition management that are unique to their institution and/or program. Quality indicators and quality improvement initiatives covering all relevant aspects of perioperative care have previously been developed for bariatric surgery (Azagury & Morton, 2016; Maggard et al., 2006). To the investigator’s knowledge however, quality assessment from a comprehensive dietetics perspective, measuring the quality of nutritional management within the bariatric surgery setting, is not yet described and therefore warrants investigation.

**Self-Reported Knowledge of Bariatric Surgical Procedures Among Bariatric Dietitians**

A knowledgeable and competent dietitian is an integral part of the bariatric multidisciplinary team, contributing to effective diagnosis and management of bariatric patients. In this study, the majority of bariatric dietitians surveyed believed they had
enough knowledge of different surgical procedures to provide safe and appropriate nutrition care. A clear understanding of the physiological mechanism of action of each procedure is essential if a bariatric dietitian is going to build rationale for postoperative diet recommendations (Isom, 2012).

**Reported Availability of Protocols for Perioperative Nutritional Care in Accredited Centers**

The main findings suggest that the majority of institutions (91.5%) have written protocols that guide the perioperative nutritional care of bariatric surgery patients, but that the content of these protocols is not standardized. There was near standardization of responsive, reactive measures but standardization of preventative, preparatory measures was deficient. Focusing on the preventative and preparatory measures, 60.5% of protocols maintained content for appropriate referral processes and procedures, but far fewer of the institutions queried used standard protocols for weight loss requirements and criteria (48.8%), liquid diet regimens (39.5%), very low-calorie and low-calorie diet regimens (32.6%), and glycemic control (32.6%).

**Weight loss requirements and criteria.** In 2011, the ASMBS issued a position on preoperative weight loss requirements before bariatric surgery. Two weight management initiatives have been proposed: physician-mandated weight loss and insurance-mandated weight loss. Physician-mandated preoperative weight loss has been suggested along with a minimum weight loss threshold of 5% to 10% of initial body weight immediately (one or two months) before bariatric surgery, citing improvements in surgical risk, reduction in technical complexity via a better visualization, reduced rate of postoperative complications, and better weight loss short-term as evidence for this
contention (Alvarado et al., 2005; Benotti et al., 2009; Collins et al., 2011; DeMaria et al., 2007a, 2007b; Eisenberg et al., 2009; Gerber et al., 2015; Huerta et al., 2008; Kulick et al., 2010; Liu et al., 2005; Still et al., 2007). However, published data at the present time are of low-level evidence and are contradictory, in part due to methodological differences between studies (Brethauer, 2011; Gerber et al., 2015). As for insurance-mandated preoperative weight loss requirements, there is no high-level evidence to support this practice (Brethauer, 2011; Kim et al., 2016). The current Position Statement of ASMBS concludes that insurance-mandated preoperative weight loss is not effective for preoperative weight loss before surgery and does not provide any postoperative outcomes benefit (Brethauer et al., 2011; Kim et al., 2016). The practice of insurance-mandated weight loss is not only scientifically unfounded but may well do more harm than good as it has contributed to the attrition of patients from bariatric surgery programs, has caused unnecessary delay with life-saving treatment, and has led to the negative progression of comorbid conditions (Brethauer et al., 2011; Kim et al., 2016). Where preoperative weight loss is indicated, consideration of specific needs and circumstances of the patients is suggested (Brethauer, 2011; Kim et al., 2016). Preoperative requirements may be at the discretion of the individual surgeon and/or institution (Ochner et al., 2012).

**Diet regimens.** Some bariatric surgical programs recommend a preoperative two- to four-week period of low-calorie diet (LCD), and very low-calorie diet (VLCD) intake that can produce a rapid loss of weight and a decrease in liver and intra-abdominal fat volume which would make the surgery easier and safer (Colles et al., 2006; Edholm et
al., 2011; Faria et al., 2015; Fris, 2004). There are two types of LCD or VLCD: normal consistency with nutrient supplementation and diets in the form of liquid meal replacements (Faria et al., 2015). The effect of a liquid meal replacement diet compared with one of normal consistency on visceral fat and metabolic profile has been examined in clinically severe obese patients preparing for bariatric surgery (Faria et al., 2015). In this study, while both diets (normal consistency and liquid) had a protective effect during the preoperative stage, patients who followed the liquid diet were more successful in achieving weight reduction. Furthermore, weight loss by liquid diet was shown to result in preferential loss of visceral fat mass concomitant with a decrease in surgical duration. Faria et al. (2015) also observed a greater decrease in blood glucose in patients after liquid diet intervention. The current Position Statement of the ASMBS as reported by Kim et al. (2016) concludes that “there is no Level I data in the surgical literature or consensus in the medical literature that has clearly identified any one dietary regimen or duration that is optimal for patients with clinically severe obesity.”

**Glycemic control.** It is clear that hyperglycemia is associated with increased mortality, morbidity, and infections in the surgical and critically ill populations (Gandhi et al., 2005; Jackson et al., 2012; Merkow et al., 2009; Kwon et al., 2013; Neil & Perdrizet, 2004; Ramos et al., 2008; Umpierrez et al., 2002; Vriesendorp et al., 2004). A protocol for managing glycemic control during the perioperative period can effectively and safely be implemented in the bariatric surgery setting, leading to a reduction in adverse surgical outcomes with a decrease in morbidity (secondary to hypoglycemia) or mortality (Rometo & Korytkowski, 2016). Perna et al. (2012) revealed that optimal
control of glucose levels had a correlation with lower inpatient postoperative hyperglycemia, more weight loss at 18 months, and greater diabetic remissions. Using stricter perioperative glycemic management protocols in patients with type 2 diabetes mellitus, previous studies were able to show resolution of diabetes at one year after bariatric surgery (Fenske et al., 2011; Zaman et al., 2017). However, the same reports demonstrated no beneficial effect of tight glycemic control on postoperative outcomes and total costs in this patient population. Nevertheless, one pilot randomized controlled trial cannot provide evidence for the correlation between strict perioperative glycemic control and diabetes resolution one year after surgery (Chuah et al., 2015). Future research, with larger scale prospective studies are needed to better examine the association between optimal perioperative glucose control and long-term diabetes resolution (Zaman et al., 2017).

**Reported Availability of Perioperative Nutrition Care Protocols for Patient-Specific Subpopulations with Complex Medical Conditions**

While the existence of a protocol on managing a subpopulation of bariatric patients with complex medical conditions before and after surgery does not guarantee compliance with the recommendations, of concern is the number of institutions that do not have protocols (34%). There is even more concern that 42.6% of respondents did not know whether or not their institution or program had a protocol. The existence of a protocol may influence daily clinical practice and outcomes of care, but routine targeted education and advertisement of protocols pertinent to their area of practice is needed to increase awareness among bariatric dietitians.
Perioperative Nutrition Risk Screening Practices Among Multidisciplines And Bariatric Dietitians in Accredited Centers

Nutritional depletion is pervasive in morbidly obese preoperative candidates and is a well-recognized complication of bariatric surgery (Aills et al., 2008; Ben-Porat et al., 2015; Mechanick et al., 2013; Peterson et al., 2016). Nutritional screening on admission as well as postsurgery can be used to further stratify nutritional risk or malnutrition in these patients. Nutritional risk stratification in surgical care is supported by current literature (Bozzetti et al., 2007; Grass et al., 2011; Hiesmayr et al., 2009; Kassin et al., 2012; Schiesser et al., 2008; Schindler et al., 2010; Sorensen et al., 2008; Sun et al., 2015). Nutritional risk is a modifiable risk factor and can be improved by nutritional support (Lawson & Daley, 2015; Sun et al., 2015). Early identification of nutritional risk and prompt treatment with repletion regimens, either by diet or supplementation, have been established showing decreased risk of serious postoperative complications (Aills et al., 2008; DiGiorgi et al., 2008; Jie et al., 2012; Mahdy et al., 2008; Peterson et al., 2016). In this study, stratifying bariatric patients by perioperative nutritional risk was reported by a lower than expected proportion of respondents, which is an important shortcoming in surgery (ASPEN Board of Directors and the Clinical Guidelines Task Force, 2002; Sorensen et al., 2008; White et al., 2012). There is concern about nutritional triage prior to operation as up to one-quarter of bariatric dietitians reported that they failed to triage their patients in sufficient time to correct a deficiency. Nutritional status has been shown to impact postoperative outcomes, with malnutrition associated with worse surgical outcomes (Mechanick et al., 2008). A simple way of improving surgical outcomes, especially in high nutritional risk patients, may include use of a preoperative checklist to
ensure a thorough nutritional screening of selective micronutrient measurements. Patients with a significant nutritional deficiency should have their surgery delayed until their deficiency is corrected and conditions for optimal surgical outcomes are met. In the postoperative period, the results of this study also show that one-quarter of bariatric dietitians do not triage patients for malnutrition diagnosis. Bariatric dietitians need to keep in mind the risk for malnutrition in these patients following surgery. One method to improve nutritional triage after surgery is to implement a protocol that mandates nutrition screening of known deficiencies that are specific to the patient’s surgical procedure. Surgical patients should be aggressively treated early in their postoperative course to prevent malnutrition (Aills et al., 2008; Alvarez-Leite, 2004).

**Self-Reported Nutritional Strategies Used by Bariatric Dietitians to Prepare Candidates for Bariatric Surgery**

As recorded in Table 9, participants reported that the nutritional strategies most “always or often” used were postoperative nutrient and daily fluid intake (100%), techniques and tips to maximize food and fluid tolerance (100%), advice on protein supplementation (97.7%), adequate hydration (97.7%), and supplementation compliance (97.7%). All of these strategies are recommended by ASMBS Allied Health Nutritional Guidelines (Aills et al., 2008). The National Institute for Health and Care Excellence (NICE) guidelines advocate tailored interventions that include patient’s individual food preferences and a flexible approach to reducing calorie intake, which was frequently “always or often” (93%) used by respondents (NICE, 2016). Very low-calorie diet product selection (63.4%) and fiber supplementation (51.2%) were “sometimes” advised by respondents. This may reflect a lack of knowledge of commercially available
products and respondent time constraints. There is limited evidence to support the inclusion of fiber supplements after bariatric surgery; however, fiber supplementation is perceived to be an intervention that is of benefit (Cumming & Isom, 2015; Faria et al., 2010; Howarth et al., 2001). A review of dietary guidelines before surgery was “always or often” used by 97.7% of respondents. This strategy can be an extremely helpful approach for patients to increase understanding, facilitate dietary adherence, encourage satisfaction, and address questions and concerns (Leahy & Luning, 2015). Strategies for dietary behavior change, associated with successful weight loss and long-term maintenance of achieved weight, were “always or often” recommended by 100% of the respondents (Sarwer et al., 2011).

Self-Reported Preoperative Patient Education Practices Among Bariatric Dietitians

The preparation for bariatric surgery is important and therefore incumbent upon bariatric dietitians to ensure that all patients undergoing surgery receive effective teaching and education beforehand. In the present study, nearly all bariatric dietitians reported the use of both verbal and written instruction when communicating about diet, lifestyle changes, and nutritional supplementation with patients undergoing bariatric surgery. The combination of verbal and written diet and lifestyle instruction enables the provision of perioperative nutrition care information to patients, which appears to improve nutrition knowledge and information retention (Taube-Schiff et al., 2016). Preoperative education and postoperative reinforcement of diet protocol that follows a staged approach are important to facilitate the progression from the liquid to solid phase while the patient recovers. Nearly all bariatric dietitians reported that they usually
provide education in a protocol-derived staged meal progression based on their patients’ surgical procedure, in agreement with AACE/TOS/ASMBS guidelines (Mechanick et al., 2013). However, only one bariatric dietitian reported that they “sometimes” provide education of staged protocol-based meal progression for surgery type.

**Multidisciplinary Team Approach in Bariatric Surgery**

The National Institutes of Health (NIH), the American College of Surgeons (ACS), and the American Society for Bariatric Surgery/Society of American Gastrointestinal and Endoscopic Surgeons (ASBS/SAGES) have acknowledged the multidisciplinary approach to patient management in bariatric surgery. To the investigator’s knowledge, multidisciplinary involvement and sphere of responsibility in patient education, nutrition management, and laboratory test ordering have not been commented upon previously.

Involvement of a dietitian adds value to the multidisciplinary model to bariatric surgery. Among health care providers, bariatric dietitians can play a fundamental role in the administration of educational interventions, particularly in the areas of dietary and lifestyle changes, behavioral modification, and principles of self-care within the bariatric surgery context (Aills et al., 2008). Previous literature showed that a dietitian-led education intervention led to the improvement of overall diet quality and a loss of significantly more weight in patients (Rachal et al., 2015). Nearly all bariatric dietitians in this study indicated that they are involved in patient education.

The Centers for Medicare and Medicaid Services (CMS) revised the proposed regulatory language for food and dietetic services in hospitals in 2014 to include clinical
privileges in the clinical setting for monitoring and evaluating patient tolerance as well as ordering therapeutic diets as authorized by medical staff and by state law; however, it does not require hospitals to grant privileges to bariatric dietitians to order laboratory studies to assess nutritional status or response to dietary intervention (CMS, 2014; Schaeffer, 2014). It remains to be seen if the CMS applied these revisions for accredited bariatric surgery centers in which bariatric dietitians play a role. Concerning laboratory test orders, this study showed that the bariatric surgeon was responsible for ordering patient labwork during the perioperative period, suggesting they have medical authority on other disciplines in the bariatric surgery setting.

**Limitations of the Current Study**

This study has limitations. First, non-response bias should be taken into account while interpreting findings. More responders were newer in the field of bariatric surgery compared with non-responders, underrepresenting experienced bariatric dietitians with many years of bariatric practice. Results from this survey are therefore likely to overestimate general bariatric dietitians’ behavior. Although the response rate was acceptable, 52% of the target population, it was lower than that of a previously published bariatric dietitian survey (Wical et al., 2010). Therefore, the ability to generalize these findings is difficult. It is possible that some individuals did not respond because they lacked the time to complete the survey and/or had no interest or saw no benefit to completing the survey. Second, the survey has not been validated by previous research and did not undergo rigorous testing for reliability. Respondent fatigue might have occurred due to the length of the survey and complexity of the survey question format.
Since the survey was anonymous, it was impossible to determine if only one dietitian from each institution answered the survey, possibly influencing the results. Third, bariatric dietitians may not be aware of all protocols available and the details on the content of the protocols, although their responses are probably representative of perioperative care delivered in their institutional bariatric surgery center. Finally, this study did not audit existing protocols and current practice. Further study on the content of specific protocols and stated practice will be an important future direction to better understand their potential impact on quality of patient care and patient outcomes.

**Implications for Clinical Practice**

Study findings have important clinical implications. Notably, 91.5% of MBSAQIP-accredited bariatric centers had written protocols available for perioperative nutritional care but the content of these protocols was not standardized, 23.4% had perioperative nutritional care protocols for a specific subpopulation of bariatric patients with complex medical conditions, and only 42.6% of respondents were unaware that perioperative nutritional care protocols for these patients were available. Specific to preoperative nutritional care, these results may lead to speculate that more than half of the institutions queried are doing an insufficient or incomplete job in preparing surgery patients preoperative for optimal success postoperative. The availability of institutions with perioperative nutritional care protocols for patients with complex medical conditions was limited. This presents an opportunity for bariatric dietitians to fill this gap. It can be surmised that if bariatric dietitians are unaware of the perioperative nutritional care of the complicated bariatric surgical patient, they may not have knowledge of specific nutrition
recommendations itself for managing this unique bariatric population appropriately before and after surgery. Targeted educational programs and advertisement of protocols to all bariatric dietitians are one way to increase awareness and to ensure that they maintain their knowledge of the standards of medical nutrition therapy for patients with diabetes mellitus, patients on dialysis before bariatric surgery, patients who have both undergone bariatric surgery and remain on dialysis, or patients who are receiving mechanical ventilation.

This study also has important implications for quality improvement. Based on the present findings, many institutions have an opportunity to ensure appropriate quality of care by mandating a protocol or checklist that encourage thorough screening of known deficiencies that are specific to the patient’s surgical procedure.

Conclusion

Standardization of perioperative nutritional management protocols was universally considered important, but the remaining factors were less consistent. There are written protocols available for perioperative nutritional care in the majority of MBSAQIP-accredited bariatric centers in the United States; however, the content of these protocols was not standardized. The results also highlight the gap in knowledge of patient-specific nutritional care protocols among surveyed bariatric dietitians and the need for routine education and advertisement of such protocols to all bariatric dietitians employed by those institutions.

Surveyed bariatric dietitians held divergent attitudes toward their institution’s current perioperative nutrition management practices. There remains an opportunity for
future quality improvement initiatives that measure the quality of nutritional management within the bariatric surgery setting. Bariatric quality improvement initiatives should target deficiencies in perioperative nutritional management unique to each institutional bariatric surgery center.

The findings also bear on current perioperative nutritional care practices in patients undergoing bariatric surgery. Variations in perioperative nutritional assessment, intervention, and monitoring were not seen amongst bariatric dietitians. There is variation in practice amongst respondents with regard to perioperative nutritional screening. Nearly all (97.5%) said they were exclusively involved in postoperative patient education. The delegation of perioperative laboratory order requests was done primarily by the bariatric surgeon.
APPENDICES
APPENDIX A

MEDICAL DIRECTOR AND PROGRAM COORDINATOR LETTER
Appendix A

Medical Director and Program Coordinator Letter

Kent State Research Inquiry
Bariatric/Weight Loss Surgery Program, attn: Medical Director and Program Coordinator
Department of Surgery

Dear Bariatric Medical Director and Program Coordinator:

I am writing to request permission to conduct a research study at your institution. I am currently enrolled in the Combined Master of Science/Dietetic Internship Program at Kent State University in Kent, OH, and am in the process of writing my Master’s Thesis. The study is entitled Protocols for perioperative nutritional care practice in accredited bariatric surgical centers: a survey of current practice.

Due to the nature of the study, I hope to recruit, at minimum, 100 bariatric registered dietitians in U.S. programs recognized as a Center of Excellence for Bariatric Surgery by the Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program to anonymously complete a survey. Interested dietitians, who volunteer to participate, will be sent an email invitation that will include a link to the survey and details explaining the survey. Dietitians who volunteer to participate will be given consent forms. The consent document will be attached in the email. The survey process should take no longer than 20-25 minutes. Survey completion will be anonymous and individual responses will be kept confidential, and completion of the survey will be taken as consent. No costs will be incurred by either your facility or the individual participants.

Your approval to conduct this study will be greatly appreciated. If you have any questions regarding this study, or would like additional information, please feel free to contact Candace Pumper at cpumper@kent.edu or Angie E. Ha, PhD at eha@kent.edu in the Department of Nutrition and Dietetics, School of Health Sciences.

I will be emailing your dietitian(s) December 2016. If you and your dietitian(s) agree, kindly submit his/her email to cpumper@kent.edu. Please include bariatric dietitians at your institution and all your affiliated facilities/locations.

Thank you so much for your time and consideration. I look forward to hearing from you.

Sincerely,
Candace Pumper
Kent State University Dietetic Intern and Graduate Student
APPENDIX B

INVITATION EMAIL TO BARIATRIC REGISTERED DIETITIANS
Appendix B

Invitation Email to Bariatric Registered Dietitians

Subject Line: Bariatric Registered Dietitian Survey Invitation

Dear Participant:

My name is Candace Pumper and I am in the Combined Master of Science/Dietetic Internship Program at Kent State University. For my Master’s Thesis, I am surveying bariatric registered dietitians to investigate the existence of protocols available for perioperative nutritional care of patients undergoing bariatric surgery in accredited centers, and determine current perioperative nutritional care practices for patients undergoing bariatric surgery. I am writing to invite you to participate in this research study by completing the attached survey.

Procedure: The 96-items questionnaire survey will include questions relating to demographics, bariatric surgical procedures performed at your facility, surgical case volume, institution policies and protocols, content of existing protocols, current perioperative nutritional care practices of the bariatric surgical patient from initial evaluation through long-term follow-up, and levels of importance and agreement with statements about perioperative nutritional management. The survey will require approximately 20-25 minutes to complete.

Risks: Participation in the survey does not place you, as the participant, at any foreseeable immediate nor future physical, psychological or emotional risk.

Benefits: There will be no direct personal benefit to you, but your participation will contribute to our understanding of current perioperative nutritional management practices in patients undergoing bariatric surgery in the United States.

Anonymity and Confidentiality: Anonymity will be protected upon completion of the survey. Responses to the survey will remain anonymous and kept confidential within the limits of the law. Only a unique computer generated code number will identify your survey responses. At no time will your personal information be associated with your responses to the survey. All data will be encrypted and stored in password-protected electronic format. The results of this study will be used for scholarly purposes only.

Voluntary Participation: Participation in this study is strictly voluntary and uncompensated, monetarily or otherwise. You may choose not to participate. If you do decide to participate, you can change your mind at any time and withdraw from the study without negative consequences. You may refuse to answer any question(s) that you do not wish to answer. You may end your participation by logging off the survey or by
closing the internet browser. If you choose to participate, please complete the survey by February 28, 2017.

**Use of Research Results:** Any identifying information will be kept in a secure location and only the researchers will have access to the data. Research participants will not be identified in any publication or presentation of research results. Results will be presented in aggregate form only. Data will be stored for five years in both a locked file and computer database, after which it will be permanently removed and destroyed.

**Future Questions:** If you have any questions concerning your participation in this study now or in the future, or if you would like a copy of the study results, you may contact Eun-Jeong (Angie) Ha, PhD at 1(330) 672-2701 or via e-mail at eha@kent.edu or Candace Pumper at cpumper@kent.edu. This research protocol and informed consent document has been reviewed and approved by the Kent State University Institutional Review Board (IRB). If you have any questions about your rights as a research participant or complaints about the research, please contact the IRB at 1(330) 672-2704.

Your responses and time are greatly appreciated. Thank you in advance for your participation.

Sincerely,

Candace Pumper
Kent State University
Dietetic Intern and Graduate Student

**Follow this link to the Survey**

Take the survey

Or copy and paste the URL below into your internet browser:

[URL Here]
APPENDIX C

REMINDER EMAIL TO NON-RESPONDERS
Appendix C

Reminder Email to Non-Responders

Subject Line: Bariatric Registered Dietitian Survey Reminder

Dear Participant:

Recently, we sent you a request to participate in an important survey of bariatric registered dietitians regarding the existence of protocols available for perioperative nutritional care and current practices associated with perioperative nutritional care of patients undergoing bariatric surgery. Please consider adding your feedback as a key member of the bariatric surgery team.

To access the survey, please click on the link below

Take the survey

Or copy and paste the URL below into your internet browser:

[URL Here]

All responses will remain confidential and your participation in this research is strictly voluntary. The deadline to complete the survey is February 28, 2017.

Your completion and submission of the questionnaire indicate your consent to participate in the study.

We apologize if you have already completed the survey and are receiving this message in error. If you have any questions concerning your participation in this study now or in the future, or if you would like a copy of the study results, you may contact Eun-Jeong (Angie) Ha, PhD at 1(330) 672-2701 or via e-mail at eha@kent.edu or Candace Pumper at cpumper@kent.edu. This research protocol and informed consent document has been reviewed and approved by the Kent State University Institutional Review Board (IRB). If you have any questions about your rights as a research participant or complaints about the research, please contact the IRB at 1(330) 672-2704.

Thank you for your participation.

Sincerely,

Candace Pumper
Kent State University
Dietetic Intern and Graduate Student
APPENDIX D

INFORMED CONSENT
Appendix D

Informed Consent

Thank you for your time and interest in completing this survey. Before taking part in this study, please read the informed consent form below and click on the "I Agree" button at the bottom of the page if you understand the statements and freely consent to participate in the study.

Purpose

The purpose of this study was to investigate the existence of protocols available for perioperative nutritional care of patients undergoing bariatric surgery in accredited centers, and determine current perioperative nutritional care practices for patients undergoing bariatric surgery.

Procedure

The 96-items questionnaire survey will include questions relating to demographics, bariatric surgical procedures performed at your facility, surgical case volume, institution policies and protocols, content of existing protocols, current perioperative nutritional care practices of the bariatric surgical patient from initial evaluation through long-term follow-up, and levels of importance and agreement with statements about perioperative nutritional management. The survey will require approximately 20-25 minutes to complete.

Risks

Participation in the survey does not place you, as the participant, at any foreseeable immediate nor future physical, psychological or emotional risk.

Benefits

There will be no direct personal benefit to you, but your participation will contribute to our understanding of current perioperative nutritional management practices in patients undergoing bariatric surgery in the United States.

Anonymity and Confidentiality

Anonymity will be protected upon completion of the survey. Responses to the survey will remain anonymous and kept confidential within the limits of the law. Only a unique computer generated code number will identify your survey responses. At no time will your personal information be associated with your responses to the survey. All data will
be encrypted and stored in password-protected electronic format. The results of this study will be used for scholarly purposes only.

**Voluntary Participation**

Participation in this study is strictly voluntary and uncompensated, monetarily or otherwise. You may choose not to participate. If you do decide to participate, you can change your mind at any time and withdraw from the study without negative consequences. You may refuse to answer any question(s) that you do not wish to answer. You may end your participation by logging off the survey or by closing the internet browser. If you choose to participate, please complete the survey by February, 28 2017.

**Use of Research Results**

Any identifying information will be kept in a secure location and only the researchers will have access to the data. Research participants will not be identified in any publication or presentation of research results. Results will be presented in aggregate form only. Data will be stored for five years in both a locked file and computer database, after which it will be permanently removed and destroyed.

**Future Questions**

If you have any questions concerning your participation in this study now or in the future, or if you would like a copy of the study results, you may contact Eun-Jeong (Angie) Ha, PhD at 1(330) 672-2701 or via e-mail at eha@kent.edu, or Candace Pumper at cpumper@kent.edu. This research protocol and informed consent document has been reviewed and approved by the Kent State University Institutional Review Board (IRB). If you have any questions about your rights as a research participant or complaints about the research, please contact the IRB at 1(330) 672-2704.

☑ I Agree to participate in this online survey. (1)
☑ I do NOT agree to participate in this online survey. (2)

If I do NOT agree to participate in this online survey is Selected, Then Skip to End of Survey
APPENDIX E

SURVEY
Appendix E

Survey

Directions. Thank you for participating in our survey. Your responses are greatly appreciated. This survey has a total of 9 sections and will take approximately 20-25 minutes to complete. Please begin with Section I: Demographics by clicking the response that best fits your description. Designated questions will provide space for typing allowing further elaboration for your responses. When you are finished answering the designated questions on your screen, please click “Next” to continue through the survey. You are not required to complete the entire survey in one sitting. Your responses will be sent securely to Qualtrics servers, and saved as part of your partial response. To revisit your survey, please click on the survey link provided in the email. Please note after 72 hours, a partially completed survey will be closed. Click the “Next” button to get started.

Demographics

Q1 What is your age? ____

Q2 What is your gender?
   ☐ Male (1)
   ☐ Female (2)
   ☐ Additional Category (3)
   ☐ Decline to State (4)

Q3 What is the highest degree you have completed?
   ☐ Bachelor's degree (1)
   ☐ Master's degree (2)
   ☐ Doctorate degree (3)

Q4 How many years have you been in practice as a Registered/Licensed Dietitian? ____

Q5 How many years have you been in practice as a Bariatric Dietitian (Clinical or Outpatient)? ____
Q6 What is your current professional status?
- Inpatient Clinical Bariatric Dietitian (1)
- Outpatient Clinical Bariatric Dietitian (2)
- Both (3)

Q7 Please indicate if you are a member of these societies. Please select all that apply.
- Academy of Nutrition and Dietetics (1)
- The American Society for Metabolic and Bariatric Surgery (2)
- Obesity Action Coalition (3)
- Weight Management Dietetic Practice Group (4)
- Society for Nutrition Education and Behavior (5)
- American Diabetes Association (6)
- Other, please specify (7)

Q8 Labor Demographics

Q9 On average, how many bariatric patients do you personally see per month (include both office and hospital encounters)?
- Less than 1 (1)
- 1-100 (2)
- 101-200 (3)
- 201-300 (4)
- 301-400 (5)
- >400 (6)

Q10 Which procedure do you see most often in your patients with bariatric surgery?
- Adjustable Gastric Banding (1)
- Roux-en-Y Gastric Bypass (2)
- Vertical Sleeve Gastrectomy (3)
- Biliopancreatic Bypass with or without Duodenal Switch (4)
- Revisions (5)
- Other (6)
Facility Demographics

Q11 Which state best describes your practice setting?
- Community Hospital (1)
- Teaching/Academic Medical Center (2)
- Specialized Hospital (e.g., facility includes specialists with expertise in the areas of esophagogastric, colorectal, pancreaticobiliary, and bariatric surgery) (3)
- Outpatient Clinic (e.g., bariatric surgery center; GI surgery (minimally invasive) clinic) (4)
- Other, please specify (5) ____________________

Q12 Does your facility have a designated inpatient unit for postoperative bariatric surgery patients?
- Yes (1)
- No (2)

If No is Selected, Then Skip to End of Block
Skip to question 14

Q13 What is the number of bariatric beds in this unit?
- 7 or less (1)
- 8-10 (2)
- 11-15 (3)
- 16-20 (4)
- 21-30 (5)
- 31-40 (6)
- >40 (7)

Section II. The next set of questions concern bariatric procedures performed at your facility and surgical case volume. Please complete the following questions regarding your facility’s current status.

Bariatric Surgery Type and Case Volume

Q14 At your facility, which surgical technique do surgeons most commonly use to perform bariatric procedures?
- Open Surgery (1)
- Laparoscopy (2)
Q15 Approximately, how many primary bariatric surgery procedures are performed annually at your facility?
- 0-50 (1)
- 51-100 (2)
- 101-150 (3)
- 151-200 (4)
- 201-300 (5)
- >301 (6)
- Don't know/Unsure (7)

Section III. The following questions survey guidelines, policies, and protocols currently used or in place within your institution. Please complete each question as appropriate at this point in time.

Institution Guidelines, Policies, and Protocols

Q16 Does your institution have a written guideline, policy, or protocol concerning preoperative nutritional management of the bariatric surgical patient?
- Yes (1)
- No (2)
- Don't Know/Unsure (3)

If No is Selected, Then Skip to End of Block
If Don't know/Unsure is Selected, Then Skip to End of Block
Skip to question 18

Q17 For those with a written guideline/policy/protocol, which of these options does your management guideline contain? Please select all that apply.
- Preoperative very low-calorie diet or low-calorie diet regimen as part of a medically supervised weight loss program (1)
- Preoperative liquid diet regimen as part of a medically supervised weight loss program (2)
- Preoperative weight loss requirements/criteria (3)
- Glycemic control (4)
- Referral processes and procedures to appropriate health professionals (5)
- Don't know/Unsure (6)
- Other, please specify (7) ____________________
Q18 Does your institution have a written guideline, policy, or protocol concerning postoperative nutritional management of the bariatric surgical patient?

- Yes (1)
- No (2)
- Don't know/Unsure (3)

If No is Selected, Then Skip to End of Block
If Don't know/Unsure is Selected, Then Skip To End of Block
Skip to question 20

Q19 For those with a written guideline/policy/protocol, which of these options does your management guideline contain? Please select all that apply.

- Management of postoperative dietary complications (1)
- Measuring clinical observations in the immediate postoperative period (2)
- Nutrition recommendations during the immediate postoperative period (3)
- Specific surgery-related dietary recommendations (4)
- Postoperative meal initiation and progression (5)
- Glycemic control (6)
- Referral processes and procedures to appropriate health professionals (7)
- Enteral and parenteral feeding/nutrition (8)
- Preventing and treating weight regain (9)
- Managing relapse (prevention/maintenance) (10)
- Don't know/Unsure (11)
- Other, please specify (12) ____________________

Q20 Does your institution have a written guideline, policy, or protocol for patient-specific subpopulations?

- Yes (1)
- No (2)
- Don't know/Unsure (3)

If No is Selected, Then Skip to End of Block
If Don't know/Unsure is Selected, Then Skip to End of Block
Skip to question 22
Q21 For those with a written guideline/policy/protocol, which of these options does your management guideline contain? Please select all that apply?
- Care of patients with type 1 diabetes mellitus (1)
- Care of patients with type 2 diabetes mellitus (2)
- Care of patients on renal dialysis before bariatric surgery (3)
- Care of patients that remain on dialysis after bariatric surgery (4)
- Patients receiving mechanical ventilation (5)
- Don't know/Unsure (6)
- Other, please specify (7) ____________________

Q22 Does your institution have a written guideline, policy, or protocol for documenting dietary compliance and adherence with prescribed supplementation regimen?
- Yes (1)
- No (2)
- Don't know/Unsure (3)

Q23 Does your institution/practice have a written guideline, policy, or protocol for measuring excess skin after extreme weight loss?
- Yes (1)
- No (2)
- Don't know/Unsure (3)
Section IV. The next set of questions ask about perioperative screening of nutritional risk in bariatric surgery patients.

**Perioperative Nutritional Risk Screening**
Please rank your area in the department on a scale from Never to Always.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Never (1)</th>
<th>Rarely (2)</th>
<th>Sometimes (3)</th>
<th>Often (4)</th>
<th>Always (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A multidisciplinary screening procedure is followed routinely before surgery to identify patients with nutrition risk. (1)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>A multidisciplinary screening procedure is followed routinely after surgery to identify patients with nutrition risk. (2)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I triage nutritional risk of surgical patients in sufficient time to correct subclinical deficiencies before surgery. (3)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I triage post-bariatric patients for malnutrition diagnosis. (4)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
Section V. The next set of questions ask about perioperative nutrition assessment of the bariatric surgery patient.

**Perioperative Nutrition Assessment**
Please rank your area in the department on a scale from never to Always.

<table>
<thead>
<tr>
<th>Description</th>
<th>Never (1)</th>
<th>Rarely (2)</th>
<th>Sometimes (3)</th>
<th>Often (4)</th>
<th>Always (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I complete a history and physical, including failed weight loss attempts, recent preoperative weight loss attempts (if required by program), past medical history, and psychological history. (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I assess for potential disordered eating in bariatric surgery candidates. (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I assess for contraindications and suitability before starting the preoperative diet protocol. (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nutrition assessments and reassessments are documented within the timeframes defined in the clinical nutrition policies. (4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical records indicate that nutrition reassessments address the status of the previous nutrition problems and progress towards goals. (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section VI. The next section surveys nutrition intervention in the areas of preoperative nutritional strategies, postoperative nutritional monitoring, perioperative supplementation, perioperative patient education, and coordination of nutrition care.

Preoperative Nutritional Strategies to Prepare Candidates for Bariatric Surgery
The following statements apply to preoperative nutritional strategies for bariatric surgery patients. Please rank your area in the department on a scale from Never to Always.
<table>
<thead>
<tr>
<th>I tailor dietary change to food preferences and allow for a flexible and individual approach to reducing calorie intake. (1)</th>
<th>Never (1)</th>
<th>Rarely (2)</th>
<th>Sometimes (3)</th>
<th>Often (4)</th>
<th>Always (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I provide instruction of postoperative nutrient and daily fluid intake recommendations. (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I advise about very low-calorie diet product selection. (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I advise about protein supplements. (4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I advise about the addition of low carbohydrate-low calorie foods. (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I advise about fiber supplementation. (6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I advise about adequate hydration. (7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I discuss the importance of supplementation compliance. (8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I discuss specific surgery-related recommendations. (9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I review dietary guidelines with the patient before surgery. (10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I discuss techniques and tips to maximize food and fluid tolerance. (11)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I advise about surgeon-specific requirements. (12)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I provide recommendations on dietary behavior change (e.g., mindful eating techniques, eating slowly, chewing foods thoroughly, eliminating carbonated beverages, eliminating sugar-sweetened beverages and concentrated sweets, eliminating high-fat foods, reducing caffeine intake, separating foods from liquids and restricting fluid intake before, with, and immediately (about 30 min.) after meals or snacks). (13)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My institution uses &quot;nil per os&quot; after midnight as an order before bariatric surgery. (14)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My institution instructs patients to drink one bottle of magnesium citrate 24 hours before bariatric surgery. (15)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My institution advises patients to drink only clear liquids for a minimum of 24 hours before surgery depending on which operation the patient will be undergoing. (16)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Postoperative Nutritional Monitoring

The following statements apply to postoperative nutritional monitoring of bariatric surgery patients. Please rank your area in the department on a scale from Never to Always.


<table>
<thead>
<tr>
<th></th>
<th>Never (1)</th>
<th>Rarely (2)</th>
<th>Sometimes (3)</th>
<th>Often (4)</th>
<th>Always (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I address and monitor adequacy of diet. (1)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I address and monitor adherence to supplementation regimen. (2)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I address and monitor food intolerance issues (nausea, vomiting, dumping). (3)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I assess and monitor food texture compliance. (4)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I reinforce dietary behavior strategies. (5)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Postoperative Diet Tolerance and Advancement

Q54 Does your program’s postoperative bariatric diet incorporate texture progression: from clear liquids to full liquids to purees to soft solids and finally to solid foods?
- Yes (1)
- No (2)

Q55 Do you discharge bariatric patients on a full liquid diet?
- Yes (1)
- No (2)

Q56 Who evaluates the patient’s tolerance to the postoperative diet? Please select all that apply.
- Physician (1)
- Bariatric Surgeon (2)
- RD/RDN (3)
- Other, please specify (4) ____________________
Q57 Who decides when a patient is ready to advance to the next phase of the postoperative diet? Please select all that apply.
- Physician (1)
- Bariatric Surgeon (2)
- RD/RDN (3)
- Other, please specify (4) ________________

**Perioperative Supplementation Regimen**

Q58 Is nutrient supplementation used routinely preoperatively in patients awaiting bariatric surgery at your institution?
- Yes (1)
- No (2)

Q59 When would you routinely start MVI-mineral supplementation after bariatric surgery at your institution?
- Day 1 after hospital discharge (1)
- Day 2 after hospital discharge (2)
- Day 3 after hospital discharge (3)
- Day 4 after hospital discharge (4)
- Day 5 after hospital discharge (5)
- Day 6 after hospital discharge (6)
- 1 week after hospital discharge (7)
- Other (8)

**Perioperative Patient Education**
Please rank your area in the department on a scale from Never to Always regarding bariatric nutrition patient education.
<table>
<thead>
<tr>
<th>Item</th>
<th>Never (1)</th>
<th>Rarely (2)</th>
<th>Sometimes (3)</th>
<th>Often (4)</th>
<th>Always (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient education materials are current, high quality, professionally presented (with reading level appropriate for 8th grade or less), and consistent with the bariatric diet guidelines.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Bariatric inpatients and outpatients receive quality nutrition education specific to assessed needs, abilities, learning preferences, and readiness to learn.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Patients receive education in a protocol-derived staged meal progression based on their surgical procedure.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Guidelines for long-term weight loss and maintenance are reviewed before bariatric surgery.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Guidelines for long-term weight loss and maintenance are reviewed after bariatric surgery.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Dietetic support encompasses the provision of dietary advice appropriate to the procedure (and outcomes).</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Preoperative education addresses the expected course of the perioperative nutritional care.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Preoperative education addresses indications and contradictions for bariatric surgery.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Instructions regarding diet, exercise, vitamin/mineral supplementation (dose, timing, precautions), and lifestyle changes are communicated with and given to patients undergoing bariatric surgery.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Education provided to inpatients is documented in the medical record.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>When outpatient education is provided, the RD/RDN documents the teaching methods used, the patient's understanding, compliance issues, if present, and follow-up plans.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Education goals are communicated to the surgical team.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Bariatric staff have adequate educational resources regarding dietary guidelines, meal progression, MVI-mineral supplementation, etc.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>For readmission, patient education and discharge planning is emphasized on a daily basis.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
Q74 Are the following health professionals routinely involved in the education regarding dietary guidelines, meal progression, MVI-supplementation regiment, etc. in your institution?

<table>
<thead>
<tr>
<th>Health Professional</th>
<th>Never (1)</th>
<th>Rarely (2)</th>
<th>Sometimes (3)</th>
<th>Often (4)</th>
<th>Always (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician (MD or DO)</td>
<td>(1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bariatric Surgeon</td>
<td>(2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Board-certified Physician Assistant</td>
<td>(3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nurse Practitioner</td>
<td>(4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgical Assistant-Certified</td>
<td>(5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Registered Nurse</td>
<td>(6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bariatric RD/RDN</td>
<td>(7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Coordination of Nutrition Care**

Q75 I make referral for a psychological evaluation, if disordered eating or history of eating disorder is present.
- Always (1)
- Often (2)
- Sometimes (3)
- Rarely (4)
- Never (5)

Q76 For what percentage of patients eligible for bariatric surgery would you request psychological review?
- All of the time (1)
- 90% or more of the time (2)
- 50% or more of the time (3)
- Less than 50% of the time (4)
- Less than 10% of the time (5)
- Not at all (6)

**Prognostic Factors for Nutrition Intervention**

Q77 What are the prognostic factors that you deem important for successful intervention outcomes for bariatric surgery patients?
- Patient compliance to program protocol (e.g., diet and supplementation regimens) (1)
- Emotional connection with food (2)
- Personal barriers (e.g., lack of stable support system, financial constraints) that allow or hinder preoperative program attendance (3)
- Patient's ability to participate in a medically supervised weight loss program (4)
- Patient's education level (5)
- Patient's commitment to all interventions instructed and motivation for change (6)
- RD/RDN's ability to communicate nutrition intervention in the patient's learning style (7)
- Other, please specify (8) ____________________

**Section VII. Dietary Discharge Instructions**

Please rank your area in the department on a scale from Never to Always regarding dietary discharge instructions for bariatric surgery.

<table>
<thead>
<tr>
<th></th>
<th>Never (1)</th>
<th>Rarely (2)</th>
<th>Sometimes (3)</th>
<th>Often (4)</th>
<th>Always (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dietary discharge instructions are communicated with patients after surgery. (1)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Written dietary discharge instructions are provided to patients after surgery. (2)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Discharge instructions incorporate medication and nutritional supplementation guidance. (3)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Discharge instructions incorporate activity/exercise instructions. (4)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Discharge instructions incorporate follow-up/referrals. (5)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
Section VIII. The following section concerns routine procedures for postoperative follow-up care and laboratory screening. Please complete the following questions regarding your department’s current status of follow-up care and laboratory screening.

Q83 How long after the bariatric surgery procedure do initial outpatient follow-ups commence in your department?
☑ 1 week postsurgery (1)
☑ 2 weeks postsurgery (2)
☑ 3 weeks postsurgery (3)
☑ 4 weeks postsurgery (4)
☑ 5 weeks postsurgery (5)
☑ 6 weeks postsurgery (6)
☑ Other, please specify (7) ____________________

Q84 What is your department’s method of postoperative follow-up for bariatric surgery patients? Please select all that apply.
☑ Phone call initiated by bariatric staff (1)
☑ Phone call initiated by patient (2)
☑ Follow-up visit (3)
☑ Other, please specify (4) ____________________

Q85 Does your department offer post-bariatric patients a follow-up care package for a minimum of two years within the bariatric service?
☑ Yes (1)
☑ No (2)

Q86 After discharge from bariatric service follow-up, are patients offered at least annual monitoring of nutritional status and appropriate supplementation according to needs after bariatric surgery?
☑ Yes (1)
☑ No (2)

Q87 Do you personally carry out long-term follow-up of your bariatric surgery patients?
☑ Yes (1)
☑ No (2)
☑ If No is Selected, Then Skip to End of Block
Q88 If yes, what are your standard investigations? (text entry)

**Laboratory Screening**

Q89 Who typically orders the majority of routine laboratory tests before and after bariatric surgical procedures in your department? Please select all that apply.

<table>
<thead>
<tr>
<th></th>
<th>Before (1)</th>
<th>After (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician (MD or DO) (1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bariatric Surgeon (2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Board-certified Physician Assistant (3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nurse Practitioner (4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgical Assistant-Certified (5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Registered Nurse (6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bariatric RD/RDN (7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Don't know (9)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q90 Please indicate if the nutrient marker listed is assessed during the corresponding operative period for the AGB. Please select all that apply.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron/Ferritin (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin B12 (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Folate (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium (4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25-OH Vitamin D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thiamin (6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc (7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selenium (8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper (9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iPTH (10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesium (11)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin A (12)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin B6 (13)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glucose (14)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q91 Please indicate if the nutrient marker listed is assessed during the corresponding operative period for the RYGB. Please select all that apply.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron/Ferritin</td>
<td></td>
<td></td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td></td>
<td></td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Folate</td>
<td></td>
<td></td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Calcium</td>
<td></td>
<td></td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>25-OH Vitamin D</td>
<td></td>
<td></td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Thiamin</td>
<td></td>
<td></td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Zinc</td>
<td></td>
<td></td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Selenium</td>
<td></td>
<td></td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Copper</td>
<td></td>
<td></td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>iPTH</td>
<td></td>
<td></td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Magnesium</td>
<td></td>
<td></td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Vitamin A</td>
<td></td>
<td></td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Vitamin B6</td>
<td></td>
<td></td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Glucose</td>
<td></td>
<td></td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
Q92 Please indicate if the nutrient marker listed is assessed during the corresponding operative period for the VSG. Please select all that apply.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron/Ferritin (1)</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Vitamin B12 (2)</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Folate (3)</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Calcium (4)</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>25-OH Vitamin D (5)</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Thiamin (6)</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Zinc (7)</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Selenium (8)</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Copper (9)</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>iPTH (10)</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Magnesium (11)</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Vitamin A (12)</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Vitamin B6 (13)</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Glucose (14)</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
<td>☑</td>
</tr>
</tbody>
</table>
Q93 Please indicate if the nutrient marker listed is assessed during the corresponding operative period for the BPD or BPD/DS. Please select all that apply.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron/Ferritin (1)</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Vitamin B12 (2)</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Folate (3)</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Calcium (4)</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>25-OH Vitamin D (5)</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Thiamin (6)</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Zinc (7)</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Selenium (8)</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Copper (9)</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>iPTH (10)</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Magnesium (11)</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Vitamin A (12)</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Vitamin B6 (13)</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Glucose (14)</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
Section IX. The final three questions survey level of importance and level of agreement with statements about perioperative nutritional management of the bariatric surgical patient.

Institutional Protocols for Providing Perioperative Nutritional Management
Please respond to the following statement by indicating level of importance that best represents your belief.

Q94 How important is a standardized process or protocol for the perioperative nutritional management of the bariatric surgical patient?
- Not at all important (1)
- Slightly important (2)
- Moderately important (3)
- Very important (4)
- Extremely important (5)

Please respond to each of the following statements by indicating level of agreement that best represents your beliefs.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree (1)</th>
<th>Disagree (2)</th>
<th>Neutral (3)</th>
<th>Agree (4)</th>
<th>Strongly Agree (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The current perioperative nutritional management of patients undergoing bariatric surgery at my institution could be improved.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have enough knowledge about each of the current popular surgical procedures (AGB, RYGB, VSG, BPD, BPD/DS) to provide safe and appropriate nutrition care for patients.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX F

ADDITIONAL DATA SET
Practice of Routine Perioperative Micronutrient Supplementation Regimens Among Accredited Centers and Bariatric Dietitians

Table 14 summarizes the practice of routine preoperative nutrient supplementation regimens in accredited centers with self-reported practices regarding the timing of initiation of multivitamin-mineral supplementation after hospital discharge for postoperative patients. Sixty-one percent of surveyed bariatric dietitians reported that their institution routinely used preoperative nutrient supplementation regimens for patients undergoing bariatric surgery; however, 39% indicated no routine use of nutrient supplementation preoperatively. In terms of postoperative supplementation, almost half of the surveyed respondents (48.8%) indicated that multivitamin-mineral supplementation commenced day one after hospital discharge. A total of 85.4% of surveyed participants reported starting supplementation within one-week post discharge from the hospital contrary to guideline recommendations, and 14.6% reported “other”.

Appendix F
Additional Data Set

Practice of Routine Perioperative Micronutrient Supplementation Regimens Among Accredited Centers and Bariatric Dietitians

Table 14 summarizes the practice of routine preoperative nutrient supplementation regimens in accredited centers with self-reported practices regarding the timing of initiation of multivitamin-mineral supplementation after hospital discharge for postoperative patients. Sixty-one percent of surveyed bariatric dietitians reported that their institution routinely used preoperative nutrient supplementation regimens for patients undergoing bariatric surgery; however, 39% indicated no routine use of nutrient supplementation preoperatively. In terms of postoperative supplementation, almost half of the surveyed respondents (48.8%) indicated that multivitamin-mineral supplementation commenced day one after hospital discharge. A total of 85.4% of surveyed participants reported starting supplementation within one-week post discharge from the hospital contrary to guideline recommendations, and 14.6% reported “other”.

Appendix F
Additional Data Set

Practice of Routine Perioperative Micronutrient Supplementation Regimens Among Accredited Centers and Bariatric Dietitians

Table 14 summarizes the practice of routine preoperative nutrient supplementation regimens in accredited centers with self-reported practices regarding the timing of initiation of multivitamin-mineral supplementation after hospital discharge for postoperative patients. Sixty-one percent of surveyed bariatric dietitians reported that their institution routinely used preoperative nutrient supplementation regimens for patients undergoing bariatric surgery; however, 39% indicated no routine use of nutrient supplementation preoperatively. In terms of postoperative supplementation, almost half of the surveyed respondents (48.8%) indicated that multivitamin-mineral supplementation commenced day one after hospital discharge. A total of 85.4% of surveyed participants reported starting supplementation within one-week post discharge from the hospital contrary to guideline recommendations, and 14.6% reported “other”.
Table 14

Practice of Routine Preoperative Micronutrient Supplementation Regimens Among MBSAQIP-Accredited Centers and Self-Reported Timing of Initiating of Multivitamin-Mineral Supplementation After Hospital Discharge for Postoperative Patients by Surveyed Bariatric Dietitians (n=41)

<table>
<thead>
<tr>
<th>Supplementation Routinely Used Preoperatively</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>25</td>
<td>61.0</td>
</tr>
<tr>
<td>No</td>
<td>16</td>
<td>39.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Timing of Initiation of MVI-Mineral Supplementation After Hospital Discharge</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>20</td>
<td>48.8</td>
</tr>
<tr>
<td>Day 2</td>
<td>2</td>
<td>4.9</td>
</tr>
<tr>
<td>Day 3</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>Day 4</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Day 5</td>
<td>3</td>
<td>7.3</td>
</tr>
<tr>
<td>Day 6</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>1 week</td>
<td>8</td>
<td>19.5</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>14.6</td>
</tr>
</tbody>
</table>

MVI = Multivitamin

Frequency Monitoring of Laboratory Testing Before and After Surgery: First-Line Laboratory Tests

Table 15 displays frequency for first-line laboratory tests by surgery type. For the entire sample, the preoperative laboratory testing was highest before AGB, RYGB, and VSG as compared to BPD/DS. With the exception of zinc, more than a third of surveyed bariatric dietitians reported pre-surgical laboratory testing for micronutrients and glucose; however, the highest reported rate of testing was only slightly above 50% before surgery. During the pre-surgical period, the prevalence of laboratory testing for micronutrient deficiencies (iron, calcium, vitamin D, zinc) and diabetes (glucose) was highest among patients seeking RYGB, as compared to patients seeking AGB or VSG. The exception
was vitamin B12, for which the testing frequency closely resembled AGB’s testing of iron and glucose, and VSG’s testing of vitamin D.

For the entire sample, few participants reported that patients who underwent BPD or BPD/DS received laboratory testing in the 1- to 12-month postoperative period as compared to AGB, RYGB, and VSG. Laboratory testing for all micronutrients and glucose was ordered most during the 6- and 12-month postsurgical time period. RYGB patients are screened for micronutrient deficiencies and diabetes (glucose) at the same frequency as AGB and VSG at one-month after surgery. The prevalence of micronutrient and glucose testing varied between AGB, RYGB, and VSG during the 3-9-month period; however, the prevalence was higher among patients after RYGB. After surgery, few participants reported that patients received laboratory testing for zinc irrespective of surgery type or time period. With the exception of zinc, annual screening of micronutrient deficiency and diabetes in AGB, RYGB, and VSG patients was between 44% and 53%.
### Table 15

**Frequencies of Testing for Routinely Recommended (First-Line) Laboratory Tests for Each Surgery Type (n= 48)**

<table>
<thead>
<tr>
<th>Laboratory Test</th>
<th>Surgery Type</th>
<th>AGB n (%)</th>
<th>RYGB n (%)</th>
<th>VSG n (%)</th>
<th>BPD/DS n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Iron/Ferritin</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td></td>
<td>27 (43.8%)</td>
<td>25 (52.1%)</td>
<td>21 (43.8%)</td>
<td>5 (10.4%)</td>
</tr>
<tr>
<td>1 mos. PO</td>
<td></td>
<td>5 (10.4%)</td>
<td>5 (10.4%)</td>
<td>5 (10.4%)</td>
<td>2 (4.2%)</td>
</tr>
<tr>
<td>3 mos. PO</td>
<td></td>
<td>10 (20.8%)</td>
<td>13 (27.1%)</td>
<td>12 (25.0%)</td>
<td>5 (10.4%)</td>
</tr>
<tr>
<td>6 mos. PO</td>
<td></td>
<td>19 (39.6%)</td>
<td>24 (50.0%)</td>
<td>21 (43.8%)</td>
<td>5 (10.4%)</td>
</tr>
<tr>
<td>9 mos. PO</td>
<td></td>
<td>5 (10.4%)</td>
<td>6 (12.5%)</td>
<td>4 (8.3%)</td>
<td>2 (4.2%)</td>
</tr>
<tr>
<td>12 mos. PO</td>
<td></td>
<td>17 (47.9%)</td>
<td>21 (43.8%)</td>
<td>20 (41.7%)</td>
<td>5 (10.4%)</td>
</tr>
<tr>
<td>ANN</td>
<td></td>
<td>23 (47.9%)</td>
<td>25 (52.1%)</td>
<td>23 (47.9%)</td>
<td>4 (8.3%)</td>
</tr>
<tr>
<td>NRM</td>
<td></td>
<td>2 (4.2%)</td>
<td>1 (2.1%)</td>
<td>2 (4.2%)</td>
<td>2 (4.2%)</td>
</tr>
<tr>
<td><strong>Vitamin B12</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td></td>
<td>17 (35.4%)</td>
<td>21 (43.8%)</td>
<td>19 (39.6%)</td>
<td>5 (10.4%)</td>
</tr>
<tr>
<td>1 mos. PO</td>
<td></td>
<td>5 (10.4%)</td>
<td>5 (10.4%)</td>
<td>5 (10.4%)</td>
<td>2 (4.2%)</td>
</tr>
<tr>
<td>3 mos. PO</td>
<td></td>
<td>9 (18.8%)</td>
<td>13 (27.1%)</td>
<td>11 (22.9%)</td>
<td>5 (10.4%)</td>
</tr>
<tr>
<td>6 mos. PO</td>
<td></td>
<td>19 (39.6%)</td>
<td>24 (50.0%)</td>
<td>20 (41.7%)</td>
<td>5 (10.4%)</td>
</tr>
<tr>
<td>9 mos. PO</td>
<td></td>
<td>5 (10.4%)</td>
<td>6 (12.5%)</td>
<td>4 (8.3%)</td>
<td>2 (4.2%)</td>
</tr>
<tr>
<td>12 mos. PO</td>
<td></td>
<td>17 (35.4%)</td>
<td>21 (43.8%)</td>
<td>19 (39.6%)</td>
<td>5 (10.4%)</td>
</tr>
<tr>
<td>ANN</td>
<td></td>
<td>23 (47.9%)</td>
<td>25 (52.1%)</td>
<td>22 (45.8%)</td>
<td>4 (8.3%)</td>
</tr>
<tr>
<td>NRM</td>
<td></td>
<td>2 (4.2%)</td>
<td>1 (2.1%)</td>
<td>2 (4.2%)</td>
<td>2 (4.2%)</td>
</tr>
<tr>
<td><strong>Calcium</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td></td>
<td>20 (41.7%)</td>
<td>22 (45.8%)</td>
<td>20 (41.7%)</td>
<td>5 (10.4%)</td>
</tr>
<tr>
<td>1 mos. PO</td>
<td></td>
<td>5 (10.4%)</td>
<td>5 (10.4%)</td>
<td>5 (10.4%)</td>
<td>5 (10.4%)</td>
</tr>
<tr>
<td>3 mos. PO</td>
<td></td>
<td>9 (18.8%)</td>
<td>14 (29.2%)</td>
<td>11 (22.9%)</td>
<td>5 (10.4%)</td>
</tr>
<tr>
<td>6 mos. PO</td>
<td></td>
<td>17 (35.4%)</td>
<td>22 (45.8%)</td>
<td>20 (41.7%)</td>
<td>5 (10.4%)</td>
</tr>
<tr>
<td>9 mos. PO</td>
<td></td>
<td>5 (10.4%)</td>
<td>6 (12.5%)</td>
<td>4 (8.3%)</td>
<td>2 (4.2%)</td>
</tr>
<tr>
<td>12 mos. PO</td>
<td></td>
<td>17 (35.4%)</td>
<td>20 (41.7%)</td>
<td>20 (41.7%)</td>
<td>5 (10.4%)</td>
</tr>
<tr>
<td>ANN</td>
<td></td>
<td>21 (43.8%)</td>
<td>24 (50.0%)</td>
<td>23 (47.9%)</td>
<td>4 (8.3%)</td>
</tr>
<tr>
<td>NRM</td>
<td></td>
<td>2 (4.2%)</td>
<td>1 (2.1%)</td>
<td>2 (4.2%)</td>
<td>2 (4.2%)</td>
</tr>
</tbody>
</table>

*Note.* First-line tests refer to routine screening tests for monitoring nutritional deficiency, inadequate oral intake, clinical status of comorbid conditions, and liver enzymes. Percentages add up to more than 100% as more than one time period could be selected per laboratory test per surgery type. AGB = Adjustable Gastric Banding; RYGB = Roux-en-Y Gastric Bypass; VSG = Vertical Sleeve Gastrectomy; BPD/DS = Biliopancreatic Diversion With/Without Duodenal Switch; PO = Postoperative; ANN = Annually; NRM = Not Routinely Measured
Table 15 (continued)

<table>
<thead>
<tr>
<th>Laboratory Test</th>
<th>AGB n (%)</th>
<th>RYGB n (%)</th>
<th>VSG n (%)</th>
<th>BPD/DS n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-OH Vit. D</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>20 (41.7)</td>
<td>24 (50.0)</td>
<td>21 (43.8)</td>
<td>5 (10.4)</td>
</tr>
<tr>
<td>1 mos. PO</td>
<td>5 (10.4)</td>
<td>5 (10.4)</td>
<td>5 (10.4)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>3 mos. PO</td>
<td>9 (18.8)</td>
<td>13 (27.1)</td>
<td>12 (25.0)</td>
<td>5 (10.4)</td>
</tr>
<tr>
<td>6 mos. PO</td>
<td>17 (35.4)</td>
<td>23 (47.9)</td>
<td>21 (43.8)</td>
<td>5 (10.4)</td>
</tr>
<tr>
<td>9 mos. PO</td>
<td>5 (10.4)</td>
<td>6 (12.5)</td>
<td>4 (8.3)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>12 mos. PO</td>
<td>15 (31.3)</td>
<td>20 (41.7)</td>
<td>20 (41.7)</td>
<td>5 (10.4)</td>
</tr>
<tr>
<td>ANN</td>
<td>22 (45.8)</td>
<td>25 (52.1)</td>
<td>24 (50.0)</td>
<td>4 (8.3)</td>
</tr>
<tr>
<td>NRM</td>
<td>3 (6.3)</td>
<td>1 (2.1)</td>
<td>1 (2.1)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>Zinc</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>7 (14.6)</td>
<td>11 (22.9)</td>
<td>10 (20.8)</td>
<td>4 (8.3)</td>
</tr>
<tr>
<td>1 mos. PO</td>
<td>3 (6.3)</td>
<td>4 (8.3)</td>
<td>3 (6.3)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>3 mos. PO</td>
<td>6 (12.5)</td>
<td>6 (12.5)</td>
<td>5 (10.4)</td>
<td>3 (6.3)</td>
</tr>
<tr>
<td>6 mos. PO</td>
<td>8 (16.7)</td>
<td>10 (20.8)</td>
<td>10 (20.8)</td>
<td>3 (6.3)</td>
</tr>
<tr>
<td>9 mos. PO</td>
<td>3 (6.3)</td>
<td>5 (10.4)</td>
<td>2 (4.2)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>12 mos. PO</td>
<td>8 (16.7)</td>
<td>8 (16.7)</td>
<td>9 (18.8)</td>
<td>4 (8.3)</td>
</tr>
<tr>
<td>ANN</td>
<td>11 (22.9)</td>
<td>13 (27.1)</td>
<td>12 (25.0)</td>
<td>4 (8.3)</td>
</tr>
<tr>
<td>NRM</td>
<td>10 (20.8)</td>
<td>11 (22.9)</td>
<td>12 (25.0)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>Glucose</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>21 (43.8)</td>
<td>24 (50.0)</td>
<td>23 (47.9)</td>
<td>5 (10.4)</td>
</tr>
<tr>
<td>1 mos. PO</td>
<td>5 (10.4)</td>
<td>6 (12.5)</td>
<td>6 (12.5)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>3 mos. PO</td>
<td>8 (16.7)</td>
<td>14 (29.2)</td>
<td>13 (27.1)</td>
<td>5 (10.4)</td>
</tr>
<tr>
<td>6 mos. PO</td>
<td>19 (39.6)</td>
<td>22 (45.8)</td>
<td>20 (41.7)</td>
<td>4 (8.3)</td>
</tr>
<tr>
<td>9 mos. PO</td>
<td>5 (10.4)</td>
<td>6 (12.5)</td>
<td>4 (8.3)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>12 mos. PO</td>
<td>16 (33.3)</td>
<td>20 (41.7)</td>
<td>19 (39.6)</td>
<td>5 (10.4)</td>
</tr>
<tr>
<td>ANN</td>
<td>22 (45.8)</td>
<td>24 (50.0)</td>
<td>22 (45.8)</td>
<td>4 (8.3)</td>
</tr>
<tr>
<td>NRM</td>
<td>3 (6.3)</td>
<td>2 (4.2)</td>
<td>2 (4.2)</td>
<td>2 (4.2)</td>
</tr>
</tbody>
</table>

Note. First-line tests refer to routine screening tests for monitoring nutritional deficiency, inadequate oral intake, clinical status of comorbid conditions, and liver enzymes. Percentages add up to more than 100% as more than one time period could be selected per laboratory test per surgery type. AGB = Adjustable Gastric Banding; RYGB = Roux-en-Y Gastric Bypass; VSG = Vertical Sleeve Gastrectomy; BPD/DS = Biliopancreatic Diversion With/Without Duodenal Switch; 25-OH Vit. D = 25-dihydroxyvitamin D; PO = Postoperative; ANN = Annually; NRM = Not Routinely Measured.
Frequency Monitoring of Laboratory Testing Before and After Surgery: Second-Line Laboratory Tests

Table 16 displays frequency of second-line laboratory tests by surgery type. For the entire sample, the rate of laboratory testing was highest among patients seeking AGB, RYGB, and VSG in the pre-surgical period, as compared to patients seeking BPD/DS. The preoperative testing prevalence for all micronutrients ranged from a low of 4.2% to 39.6%. In the postoperative setting, the prevalence of laboratory testing of any micronutrient and iPTH increased for all bariatric surgery types during the 1- to 12-month period. During the first postoperative month, testing rates were similar for AGB, RYGB, and VSG. The prevalence of laboratory testing for folate, thiamin, and iPTH was highest during the 6- and 12-month period for patients who underwent AGB, RYGB, and VSG. The prevalence of folate, thiamin, and iPTH testing varied between AGB, RYGB, and VSG during the 3- to 9-month period; however, the laboratory tests were completed more in patients after RYGB. Annual screening of folate and thiamin deficiency and iPTH in AGB, RYGB, and VSG patients was between 25% and 50%. Respondents at approximately 25% of practices reported that laboratory testing for selenium, copper, magnesium, and vitamins A and B6 is not routine in post-AGB, -RYGB, and -VSG patients during all time periods.
Table 16

Frequencies of Testing for Second-Line Laboratory Tests for Each Surgery Type (n = 48)

<table>
<thead>
<tr>
<th>Laboratory Test</th>
<th>AGB n (%)</th>
<th>RYGB n (%)</th>
<th>VSG n (%)</th>
<th>BPD/DS n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Folate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>14 (29.2)</td>
<td>20 (21.7)</td>
<td>19 (39.6)</td>
<td>4 (8.3)</td>
</tr>
<tr>
<td>1 mos. PO</td>
<td>5 (10.4)</td>
<td>5 (10.4)</td>
<td>5 (10.4)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>3 mos. PO</td>
<td>9 (18.8)</td>
<td>11 (22.9)</td>
<td>9 (18.8)</td>
<td>3 (6.3)</td>
</tr>
<tr>
<td>6 mos. PO</td>
<td>17 (35.4)</td>
<td>23 (47.9)</td>
<td>19 (39.6)</td>
<td>3 (6.3)</td>
</tr>
<tr>
<td>9 mos. PO</td>
<td>5 (10.4)</td>
<td>5 (10.4)</td>
<td>3 (6.3)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>12 mos. PO</td>
<td>16 (33.3)</td>
<td>20 (41.7)</td>
<td>17 (35.4)</td>
<td>4 (8.3)</td>
</tr>
<tr>
<td>ANN</td>
<td>21 (43.8)</td>
<td>24 (50.0)</td>
<td>21 (43.8)</td>
<td>4 (8.3)</td>
</tr>
<tr>
<td>NRM</td>
<td>3 (6.3)</td>
<td>2 (4.2)</td>
<td>3 (6.3)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td><strong>Thiamin</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>9 (18.8)</td>
<td>16 (33.3)</td>
<td>13 (27.1)</td>
<td>4 (8.3)</td>
</tr>
<tr>
<td>1 mos. PO</td>
<td>4 (8.3)</td>
<td>5 (10.4)</td>
<td>5 (10.4)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>3 mos. PO</td>
<td>7 (14.6)</td>
<td>12 (25.0)</td>
<td>9 (18.8)</td>
<td>5 (10.4)</td>
</tr>
<tr>
<td>6 mos. PO</td>
<td>13 (27.1)</td>
<td>20 (41.7)</td>
<td>19 (39.6)</td>
<td>3 (6.3)</td>
</tr>
<tr>
<td>9 mos. PO</td>
<td>3 (6.3)</td>
<td>5 (10.4)</td>
<td>3 (6.3)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>12 mos. PO</td>
<td>11 (22.9)</td>
<td>17 (35.4)</td>
<td>16 (33.3)</td>
<td>4 (8.3)</td>
</tr>
<tr>
<td>ANN</td>
<td>16 (33.3)</td>
<td>22 (45.8)</td>
<td>19 (39.6)</td>
<td>3 (6.3)</td>
</tr>
<tr>
<td>NRM</td>
<td>6 (12.5)</td>
<td>3 (6.3)</td>
<td>4 (8.3)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td><strong>Selenium</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>5 (10.4)</td>
<td>7 (14.6)</td>
<td>6 (12.5)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>1 mos. PO</td>
<td>2 (4.2)</td>
<td>3 (6.3)</td>
<td>2 (4.2)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>3 mos. PO</td>
<td>4 (8.3)</td>
<td>3 (6.3)</td>
<td>2 (4.2)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>6 mos. PO</td>
<td>5 (10.4)</td>
<td>6 (12.5)</td>
<td>6 (12.5)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>9 mos. PO</td>
<td>1 (2.1)</td>
<td>3 (6.3)</td>
<td>1 (2.1)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>12 mos. PO</td>
<td>4 (8.3)</td>
<td>5 (10.4)</td>
<td>4 (8.3)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>ANN</td>
<td>7 (14.6)</td>
<td>8 (16.7)</td>
<td>7 (14.6)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>NRM</td>
<td>12 (25.0)</td>
<td>14 (29.2)</td>
<td>14 (29.2)</td>
<td>4 (8.3)</td>
</tr>
</tbody>
</table>

*Note.* Second-line tests refer to diagnostic tests performed on patients in a specified clinical situation, e.g., assessment of folate, copper, and selenium in anemic patients without evidence of iron deficiency. Percentages add up to more than 100% as more than one time period could be selected per laboratory test per surgery type. AGB = Adjustable Gastric Banding; RYGB = Roux-en-Y Gastric Bypass; VSG = Vertical Sleeve Gastrectomy; BPD/DS = Biliopancreatic Diversion With/Without Duodenal Switch; PO = Postoperative; ANN = Annually; NRM = Not Routinely Measured
Table 16 (continued)

<table>
<thead>
<tr>
<th>Laboratory Test</th>
<th>AGB n (%)</th>
<th>RYGB n (%)</th>
<th>VSG n (%)</th>
<th>BPD/DS n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>4 (8.3)</td>
<td>7 (14.6)</td>
<td>6 (12.5)</td>
<td>4 (8.3)</td>
</tr>
<tr>
<td>1 mos. PO</td>
<td>2 (4.2)</td>
<td>3 (6.3)</td>
<td>2 (4.2)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>3 mos. PO</td>
<td>4 (8.3)</td>
<td>4 (8.3)</td>
<td>3 (6.3)</td>
<td>3 (6.3)</td>
</tr>
<tr>
<td>6 mos. PO</td>
<td>6 (12.5)</td>
<td>6 (12.5)</td>
<td>6 (12.5)</td>
<td>3 (6.3)</td>
</tr>
<tr>
<td>9 mos. PO</td>
<td>2 (4.2)</td>
<td>4 (8.3)</td>
<td>2 (4.2)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>12 mos. PO</td>
<td>5 (10.4)</td>
<td>5 (10.4)</td>
<td>4 (8.3)</td>
<td>3 (6.3)</td>
</tr>
<tr>
<td>ANN</td>
<td>8 (16.7)</td>
<td>8 (16.7)</td>
<td>7 (14.6)</td>
<td>3 (6.3)</td>
</tr>
<tr>
<td>NRM</td>
<td>12 (25.0)</td>
<td>15 (31.3)</td>
<td>15 (31.3)</td>
<td>3 (6.3)</td>
</tr>
<tr>
<td>iPTH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>77 (14.6)</td>
<td>10 (20.8)</td>
<td>10 (20.8)</td>
<td>3 (6.3)</td>
</tr>
<tr>
<td>1 mos. PO</td>
<td>2 (4.2)</td>
<td>2 (4.2)</td>
<td>2 (4.2)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>3 mos. PO</td>
<td>4 (8.3)</td>
<td>4 (8.3)</td>
<td>4 (8.3)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>6 mos. PO</td>
<td>10 (20.8)</td>
<td>12 (25.0)</td>
<td>11 (22.9)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>9 mos. PO</td>
<td>2 (4.2)</td>
<td>2 (4.2)</td>
<td>2 (4.2)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>12 mos. PO</td>
<td>10 (20.8)</td>
<td>10 (20.8)</td>
<td>11 (22.9)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>ANN</td>
<td>12 (25.0)</td>
<td>13 (27.1)</td>
<td>14 (29.2)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>NRM</td>
<td>9 (18.8)</td>
<td>9 (18.8)</td>
<td>8 (16.7)</td>
<td>3 (6.3)</td>
</tr>
<tr>
<td>Magnesium</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>7 (14.6)</td>
<td>11 (22.9)</td>
<td>9 (18.8)</td>
<td>3 (6.3)</td>
</tr>
<tr>
<td>1 mos. PO</td>
<td>3 (6.3)</td>
<td>4 (8.3)</td>
<td>3 (6.3)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>3 mos. PO</td>
<td>2 (4.2)</td>
<td>4 (8.3)</td>
<td>3 (6.3)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>6 mos. PO</td>
<td>7 (14.6)</td>
<td>9 (18.8)</td>
<td>9 (18.8)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>9 mos. PO</td>
<td>1 (2.1)</td>
<td>3 (6.3)</td>
<td>1 (2.1)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>12 mos. PO</td>
<td>7 (14.6)</td>
<td>9 (18.8)</td>
<td>8 (16.7)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>ANN</td>
<td>9 (18.8)</td>
<td>11 (22.9)</td>
<td>10 (20.8)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>NRM</td>
<td>11 (22.9)</td>
<td>10 (20.8)</td>
<td>11 (22.9)</td>
<td>3 (6.3)</td>
</tr>
</tbody>
</table>

*Note.* Second-line tests refer to diagnostic tests performed on patients in a specified clinical situation, e.g., assessment of folate, copper, and selenium in anemic patients without evidence of iron deficiency. Percentages add up to more than 100% as more than one time period could be selected per laboratory test per surgery type. AGB = Adjustable Gastric Banding; RYGB = Roux-en-Y Gastric Bypass; VSG = Vertical Sleeve Gastrectomy; BPD/DS = Biliopancreatic Diversion With/Without Duodenal Switch; iPTH = intact Parathyroid Hormone; PO = Postoperative; ANN = Annually; NRM = Not Routinely Measured
Table 16 (continued)

<table>
<thead>
<tr>
<th>Laboratory Test</th>
<th>AGB</th>
<th>RYGB</th>
<th>VSG</th>
<th>BPD/DS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>6 (12.5)</td>
<td>10 (20.8)</td>
<td>9 (18.8)</td>
<td>4 (8.3)</td>
</tr>
<tr>
<td>1 mos. PO</td>
<td>3 (6.3)</td>
<td>4 (8.3)</td>
<td>3 (6.3)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>3 mos. PO</td>
<td>4 (8.3)</td>
<td>5 (10.4)</td>
<td>4 (8.3)</td>
<td>4 (8.3)</td>
</tr>
<tr>
<td>6 mos. PO</td>
<td>7 (14.6)</td>
<td>9 (18.8)</td>
<td>9 (18.8)</td>
<td>3 (6.3)</td>
</tr>
<tr>
<td>9 mos. PO</td>
<td>2 (4.2)</td>
<td>4 (8.3)</td>
<td>2 (4.2)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>12 mos. PO</td>
<td>6 (12.5)</td>
<td>7 (14.6)</td>
<td>6 (12.5)</td>
<td>5 (10.4)</td>
</tr>
<tr>
<td>ANN</td>
<td>9 (18.8)</td>
<td>12 (25.0)</td>
<td>10 (20.8)</td>
<td>4 (8.3)</td>
</tr>
<tr>
<td>NRM</td>
<td>12 (25.0)</td>
<td>11 (22.9)</td>
<td>12 (25.0)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>Vitamin B6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>8 (16.7)</td>
<td>11 (22.9)</td>
<td>8 (16.7)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>1 mos. PO</td>
<td>2 (4.2)</td>
<td>3 (6.3)</td>
<td>2 (4.2)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>3 mos. PO</td>
<td>4 (8.3)</td>
<td>7 (14.6)</td>
<td>5 (10.4)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>6 mos. PO</td>
<td>9 (18.8)</td>
<td>12 (25.0)</td>
<td>10 (20.8)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>9 mos. PO</td>
<td>1 (2.1)</td>
<td>3 (6.3)</td>
<td>1 (2.1)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>12 mos. PO</td>
<td>6 (12.5)</td>
<td>8 (16.7)</td>
<td>7 (14.6)</td>
<td>2 (4.2)</td>
</tr>
<tr>
<td>ANN</td>
<td>9 (18.8)</td>
<td>11 (22.9)</td>
<td>9 (18.8)</td>
<td>1 (2.1)</td>
</tr>
<tr>
<td>NRM</td>
<td>11 (22.9)</td>
<td>9 (18.8)</td>
<td>11 (22.9)</td>
<td>4 (8.3)</td>
</tr>
</tbody>
</table>

Note. Second-line tests refer to diagnostic tests performed on patients in a specified clinical situation, e.g., assessment of folate, copper, and selenium in anemic patients without evidence of iron deficiency. Percentages add up to more than 100% as more than one time period could be selected per laboratory test per surgery type. AGB = Adjustable Gastric Banding; RYGB = Roux-en-Y Gastric Bypass; VSG = Vertical Sleeve Gastrectomy; BPD/DS = Biliopancreatic Diversion With/Without Duodenal Switch; PO = Postoperative; ANN = Annually; NRM = Not Routinely Measured.
Routine Procedures for Postoperative Follow-up Care

Table 17 represents the responses to questions about routine procedures for follow-up care. Two-thirds of bariatric dietitians (66.7%) reported that their departments preferred to follow-up with patients during scheduled visit within one week after surgery (45.7%). A little less than 60% of participants reported a follow-up care package for a minimum of two years within the bariatric surgery service was not offered to patients. A majority of participants (97%) reported that their departments offer at least annual monitoring of nutritional status and supplementation. Just over two-thirds of respondents (68.5%) personally carried out long-term follow-up of patients after surgery. The most frequently cited standardized investigations at follow-up visits were body composition analysis, biochemical surveillance, dietary adherence, supplement compliance, gastrointestinal tolerance, barriers to behavior changes/stressors, dieting histories, eating habits, physical activity (including overall enthusiasm towards it), resolution of patient medical history, and improved comorbid conditions (data not shown).
Table 17

Routine Procedures for Postoperative Follow-up Care in MBSAQIP-Accredited Centers as Reported by the Surveyed Bariatric Dietitians

<table>
<thead>
<tr>
<th>Timing of Initial Follow-up</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 week postsurgery</td>
<td>16</td>
<td>45.7</td>
</tr>
<tr>
<td>2 weeks postsurgery</td>
<td>11</td>
<td>31.4</td>
</tr>
<tr>
<td>3 weeks postsurgery</td>
<td>1</td>
<td>2.9</td>
</tr>
<tr>
<td>4 weeks postsurgery</td>
<td>7</td>
<td>20.0</td>
</tr>
<tr>
<td>5 weeks postsurgery</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>6 weeks postsurgery</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Preferred Method of Follow-up</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phone call initiated by bariatric staff</td>
<td>15</td>
<td>31.3</td>
</tr>
<tr>
<td>Phone call initiated by patient</td>
<td>1</td>
<td>2.1</td>
</tr>
<tr>
<td>Follow-up visit</td>
<td>32</td>
<td>66.7</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
<td>100.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Follow-up Care Packages Offered Minimum Two Years</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>14</td>
<td>42.4</td>
</tr>
<tr>
<td>No</td>
<td>19</td>
<td>57.6</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Annual Monitoring of Nutritional Status Supplementation</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>32</td>
<td>97.0</td>
</tr>
<tr>
<td>No</td>
<td>1</td>
<td>3.0</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bariatric Dietitian Carries Out Long-Term Follow-up</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>24</td>
<td>68.6</td>
</tr>
<tr>
<td>No</td>
<td>11</td>
<td>31.4</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Health Care Provider Responsible for the Evaluation of Diet Tolerance and Advancement of Diet During the Postoperative Period

Bariatric dietitians were asked to identify the health care provider responsible for the evaluation of diet tolerance and advancement of diet during the postoperative period.

Bariatric dietitians and surgeons evaluated dietary tolerance and advised when to advance to the next phase of the postoperative diet more frequently, whereas physicians evaluated
and advised the postoperative diet less frequently (Table 18). Nearly a third of all respondents (31.3%) indicated other health care providers were obliged to evaluate postoperative diet tolerance and advance to the next phase of the diet. Some indicated the physician assistant responsible, whereas others reported the advanced practitioner (e.g., nurse practitioner), nursing staff, or mid-level professionals were responsible (data not shown). Specific for advancing next phase of the diet, one respondent deemed the patient responsible: “Patient as per own tolerance and guidelines.” Another respondent indicated that “diet progression is the same for all patients – unless otherwise needed to adjust – patients receive this information in a preoperative nutrition education class about two weeks prior to surgery, but also receive a patient manual outlining this and other information early-on once starting the program.”

Table 18

<table>
<thead>
<tr>
<th>Health Care Provider</th>
<th>Preoperative n (%)</th>
<th>Postoperative n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician (MD or DO)</td>
<td>5 (10.4)</td>
<td>5 (10.4)</td>
</tr>
<tr>
<td>Bariatric Surgeon</td>
<td>29 (60.4)</td>
<td>26 (54.2)</td>
</tr>
<tr>
<td>Bariatric Dietitian</td>
<td>37 (77.1)</td>
<td>28 (58.2)</td>
</tr>
<tr>
<td>Other</td>
<td>15 (31.3)</td>
<td>15 (31.3)</td>
</tr>
</tbody>
</table>

*Note.* Percentages add up to more than 100% as more than one health care provider could be selected for postoperative diet tolerance evaluation and diet advancement.
REFERENCES
REFERENCES


Cavin, J. B., Couvelard, A., Lebtahi, R., Ducroc, R., Arapis, K., Voitellier, E., Cluzeaud, F. … & Le Gall, M. (2016). Différences in alimentary glucose absorption and


percent excess weight loss after 6 to 8 years with 93% follow-up. *Annals of Surgery*, 256(2), 262-265.


Musso, G., Cassader, M., Olivetti, C., Rosina, F., Carbone, G., & Gambino, R. (2013). Association of obstructive sleep apnoea with the presence and severity of non-alcoholic fatty liver disease: a systematic review and meta-analysis. *Obesity Reviews, 14*(5), 417-431.


Patti, M. E., Houten, S. M., Bianco, A. C., Bernier, R., Larsen, P. R., Holst, J. J., Badman, M. K., ... & Goldfine, A. B. (2009). Serum bile acids are higher in humans with prior gastric bypass: potential contribution to improved glucose and lipid metabolism. *Obesity (Silver Spring), 17*(9), 1671-1677.


Ramos, M., Khalpey, Z., Lipsitz, S., Steinberg, J., Panizales, M. T., Zinner, M., & Rogers, S. O. (2008). Relationship of perioperative hyperglycemia and


apnea. *American Journal of Respiratory and Critical Care Medicine, 190*(8), 930-937.


Banding surgery on plasma levels of appetite-control, insulinotropic, and digestive hormones. *Obesity Surgery, 18*(9), 1089-1096.


disease and hepatocellular carcinoma: a weighty connection. *Hepatology, 51*(5),
1820-1832.

gastric bypass surgery on rat intestinal glucose transport. *American Journal of
Physiology Gastrointestinal and Liver Physiology, 297*(5), G950-G957.

Stefater, M. A., & Wilson-Pérez, H. E., Chambers, A. P., Sandoval, D. A., & Seeley, R.
J. (2012). All bariatric surgeries are not created equal: insights from mechanistic

thromboembolism. *The American Journal of Medicine, 118*(9), 978-980.

Stienstra, R., Duval, C., Müller, M., & Kersten, S. (2007). PPARs, Obesity, and

Still, C., D., Benotti, P., Wood, G., C., Gerhard, G., S., Petrick, A., Reed, M., & Strodel,
undergoing gastric bypass surgery. *Archives of Surgery, 142*(10), 994-998.

J. (2005). Weight loss through ileal transposition is accompanied by increased
ileal hormone secretion and synthesis in rats. *American Journal of Physiology-

*Obesity Surgery, 15*(9), 1347-1351.

*JAMA, 256*(1), 51-54.


The American College of Surgeons (ACS) & the American Society for Metabolic and Bariatric Surgery (ASMBS). (2016). *Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) standards manual V2.0 resources for optimal care of the metabolic and bariatric surgery patient* (2nd ed.).


