OBESITY YEARS: CLINICAL VARIATION BY AGE PRE/POST BILIOPANCREATIC DIVERSION/DUODENAL SWITCH (BPD/DS)

M.L. Gott¹, P.R. Osterdahl², G.J. Slotman¹; ¹Inspira Health Network, Department Of Surgery, Vineland, NJ, USA; ²Inspira Health Network, Department Of Obstetrics/Gynecology, Vineland, NJ, USA

Corresponding author:
Gus J Slotman, M.D., FACS, FCCM, FCCP, FASMBS
Director of Clinical Research
Inspira Health Network
Clinical Professor of Surgery Rowan University
1505 West Sherman Avenue, Suite B
Vineland, New Jersey 08028
Tel: 856-641-8635
Fax: 856-641-8636 Email: slotmang@ihn.org

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Abstract:

Background: Pre-operative conditions and bariatric surgery outcomes vary in older versus younger patients with super obesity. However, whether or not these conditions vary strictly by age is unknown. Objective: To identify clinical variation by age, pre/post BPD/DS.

Materials and Methods: 1673 BPD/DS patients from the Surgical Review Corporation’s BOLD database were analyzed retrospectively by age: <30(177), 30-40(456), 40-50(486), 50-60(407), 60-70(138), >70(9). Data: Demographics, BMI and 33 obesity co-morbidities. Statistics: ANOVA and General Linear Models including pre- and post-operative data modified for binomial distribution of dichotomous variables.

Results: Pre-op BMI varied inversely by age, from <30 (55+10) to >70 (44+8) p<0.01, as did 12-month BMI <30 (32+6) to 60-70 (31+5) p<0.05. Female/male (p<0.05), race and health insurance (p<0.0001) varied by age. Gout varied directly and tobacco abuse inversely by age at baseline. 12-month liver disease, and pulmonary hypertension varied directly by age. Hernia, cholelithiasis, CHF, impaired function, diabetes, hypertension, dyslipidemia, lower extremity edema (LEE), somatic pain (MS pain), angina, sleep apnea, stress urinary incontinence (SUI) varied directly pre-operatively, and post-operatively to 12 months. In >60 patients, angina, MS pain, LEE and SUI increased from baseline after undergoing BPD/DS

Conclusion: In spite of lower pre-operative and 12-month BMI in older BPD/DS patients, baseline co-morbidities varied directly with age, and post-operative resolution of 12 weight-related problems was inversely proportional to age. Only diabetes resolved better among older patients. These findings suggest the concept of “obesity years”, wherein patients carrying obesity the longest accumulate more co-morbidities and resolve them less.
Introduction:

Age has long been a stand-alone non-modifiable risk factor for development of co-morbidities regardless of obesity status. For example, hypertension, while being a highly preventable disease, has the greatest incidence among older adults. Using a clustering approach, Alhasoun et al found that age increased the risk of hypertension, heart failure, GERD, and musculoskeletal disorders. There are several comorbidities that are noted to decrease with age, however, including HIV/AIDS and obesity.

Numerous studies have demonstrated strong links between obesity and noncommunicable diseases. The association between obesity and US men’s and women’s mortality risk has clearly been shown to grow substantially stronger with age. Elevated BMI has a profound impact on a person’s body; increasing the risk for musculoskeletal, cardiovascular, endocrine, psychiatric, and neoplastic diseases. Excess body weight accounted for approximately 4 million deaths in 2017, with 70% attributed to cardiovascular disease. Bowman et al demonstrated that the incidence of diabetes and coronary heart disease in obese patients were increased for all ages up to age 84 and is associated with shorter overall survival.

Bariatric surgery, including, Roux-en-Y gastric bypass, sleeve gastrectomy, and BPD/DS have been proven to be both safe and effective in improving co morbidities related to obesity with studies showing that age should not preclude a patient from receiving bariatric surgery. Pata et al demonstrated that, following BPD/DS, diabetes, HTN, triglyceride levels, and cholesterol levels improve significantly within 1 year of the procedure. Additionally, Michaud et al found that BPD-DS resulted in resolution of obesity-related co-morbidities, but they did not stratify this result by age group. However, whether or not pre-operative clinical characteristics of super-obese patients undergoing BPD/DS vary directly by age and the
effect of increasing age on BPD/DS outcomes are unknown. The objective of this study was to identify variation by decade age groups in pre-operative data post-BPD/DS results.

**MATERIALS AND METHODS:**

With the approval of the Data Access Committee of the Surgical Review Corporation and the IRB of Our Lady of Lourdes Medical Center, Camden NJ, pre-operative and follow-up data at 2, 6, 12, 18 and 24 months after surgery on 1,673 patients from the Surgical Review Corporation’s (SRC) Outcomes Longitudinal Database (BOLD) who underwent BPD/DS at SRC Centers of Excellence in Bariatric Surgery (COEBS) was analyzed retrospectively in six groups by age decade: <30(n=177), 30-40(n=456), 40-50(n=486), 50-60(n=407), 60-70(n=138), >70(n=9)

Data included age, weight, BMI, and 31 weight-related medical conditions: hypertension (HTN), angina, congestive heart failure (CHF), peripheral vascular disease (PVD), obstructive sleep apnea (OSA), obesity hypoventilation syndrome (OHS), asthma, ischemic heart disease, abdominal hernia, abdominal panniculitis, cholelithiasis, gastroesophageal reflux disease (GERD), liver disease, stress urinary incontinence, diabetes mellitus, gout, dyslipidemia, pseudotumor cerebri, back pain, lower extremity edema and musculoskeletal pain, mental health diagnoses, impaired functional status, depression, psychological impairment, alcohol use, substance abuse, and tobacco use.

Statistical analysis: Differences among age groups were examined at each time point using t-test for continuous variables (weight, weight loss and BMI) and chi-square equation to examine association of age with categorical variables (co-morbidities). To find the differences by age for continuous values while adjusting for baseline value, a linear model was created with age and baseline value as factors, for each post-baseline time point. Pair-wise comparisons were examined using least squares means (baseline adjusted means) calculated from the model to find differences in the age groups while adjusting for
baseline. The differences in obesity co-morbidities with age were examined by using a categorical model while adjusting for baseline co-morbidities in a similar fashion but using a more appropriate categorical model.10

RESULTS:

At 2 months post operatively the numbers of patients available for analysis by age (<30, 30-40, 40-50, 50-60, 60-70, >70) were 186, 445, 466, 393, 129, and 9 respectively (total=1628), at 6 months: 99, 273, 300, 279, 97, 8, (total=1056), at 12 months: 51, 143, 174, 184, 64, 5 (total=621), at 18 months: 10, 49, 66, 69, 36, 4 (total=234), and at 24 months: 7, 27, 43, 50, 12, 2 (total=141).

Weight, BMI, and weight loss are displayed in Table 1. The youngest age groups had the highest starting weights and BMIs prior to undergoing BPD/DS. Pre-operatively and at 2- and 6-months post-BPD/DS weight and BMI decreased directly with increasing age, from <30 years to >70. By 12 months post-op, BMI and weight were similar in all age groups, but still statistically lower in >70 versus <30. Overall weight loss was greatest in the younger age groups. At 24 months post-op BMI remained lowest in the <70 group.

Cardiopulmonary obesity comorbidities are tabulated in table 2. Prior to surgery and 2, 6, and 12 months after BPD/DS CHF, HTN, OSA, and angina varied directly with increasing age. By 18 months post-op OSA no longer varied by age. Pulmonary hypertension varied by age only at 12 months post-op. At 24 months post-BPD/DS rates of HTN and angina remained higher in older patients. Peripheral vascular disease, pulmonary hypertension, asthma, and obesity hypoventilation did not vary by age. At 18 months, HTN and angina, impaired functional status, LEE, MS pain, SUI, still varied directly by increasing age. Among patients >60 few cardiopulmonary co-morbidities improved in frequency after BPD/DS.
Metabolic and endocrine co-morbidities are listed in Table 3. Diabetes mellitus and dyslipidemia affected older patients more frequently before surgery and at 2, 6, and 12 months post-op. In the <30 age group diabetes decreased 32.8% from baseline at 12 months, compared with 84.4%, 81.0%, 81.1%, 55.3%, and 70.0% reduction in the 30-40, 40-50, 50-60, 60-70, and >70 age groups respectively. Gout varied directly with age intermittently through 18 months. Pseudotumor cerebri did not vary by age.

Abdominal and hepatobiliary co-morbidities are presented in Table 4. Preoperatively and at 2, 6, and 12 months following BPD/DS the frequencies of cholelithiasis, stress urinary incontinence, and abdominal hernia all correlated directly with increasing age. Abdominal panniculitis, GERD, and liver disease did not vary at baseline. At 12 months GERD and liver disease occurred more frequently in older patients. Stress urinary incontinence prevalence varied directly by age through 18 months.

Somatic co-morbidities are presented in table 5. Older patients had significantly higher rates of lower extremity edema and musculoskeletal pain preoperatively and at 2, 6, and 12 months post-op. Reduction in the rate of musculoskeletal pain at 2, 6, and 12 months-occurred only in patients less than 60. Impaired functional status correlated directly with age before surgery and at 2- and 6-months post-op. Back pain did not vary significantly at any interval.

Psychological and Behavioral co-morbidities are summarized in Table 6. Mental health diagnosis and physiological impairment did not vary post-operatively except in the >70-year group at 24 months. Tobacco use and depression varied inversely by age preoperatively. Individuals between the ages of 40-60 had the highest rates of depression and tobacco use, which decreased with increasing age.
Numerically, in the six age groups, none of the psychological/behavioral problems improved dramatically post-BPD/DS.

Panniculitis, alcohol/substance use, asthma, obesity hypoventilation, PVD, back pain, mental health, depression, psychological impairment, pseudotumor cerebri, irregular menses, and DVT/PE did not vary by age.

Discussion:

The results of this study identify significant variation by age in the pre-operative clinical characteristics of super-obese patients undergoing BPD/DS, and in their post-BPD/DS outcomes. Pre-operative weight and BMI, and post-BPD/DS weight, weight loss, and BMI varied inversely by increasing age, a statistically significant gap even at 24 months when BMI was nearly identical clinically. However, in spite of lower BMI with increasing age, the cardiovascular co-morbidities hypertension, congestive heart failure, angina, and dyslipidemia varied directly by age at baseline and, adding pulmonary hypertension, post-operatively as well, the age differential persisting through 24 months for hypertension and dyslipidemia. Prevalence of these issues changed little with weight loss among >60 patients. Obstructive sleep apnea varied directly with age, baseline through 12 months. Pre-operative diabetes varied directly with age, but then, resolved to the greatest extent among >60 patients. Incidences of abdominal hernia, cholelithiasis, and stress conversely incontinence increased with age at baseline, and, with 12-month liver disease, varied by age post-operatively. Older patients also had the highest rates of impaired functional status, lower extremity edema and musculoskeletal pain, both pre- and post-BPD/DS, and only functional status improved with weight loss. Finally, analysis of psychological and behavioral comorbidities revealed more frequent pre-operative smoking and 2- to 6-month depression among
younger patients. Psychological/behavioral problems did not improve from baseline in any age group. Among patients >60, angina, MS pain, LEE and SUI actually increased from baseline following BPD/DS. Panniculitis, alcohol/substance use, asthma, obesity hypoventilation, PVD, back pain, fibromyalgia, mental health diagnosis, depression, psychological impairment, pseudotumor cerebri, irregular menses, DVT/PE did not vary by age. Our review of the literature indicates that the pre- and post-BPD/DS clinical variations by decade age groups observed here have not been reported previously and are important findings of this investigation.

Pre-operative weight and BMI were highest for the youngest patients in this study, as was post-BPD/DS weight loss. The <30 group suffered the fewest somatic comorbidities, least impaired functional status, and lower rates of potentially disabling cardiopulmonary, endocrine/metabolic, and abdominal/hepatobiliary co-morbidities, likely yielding higher tolerance for cardiovascular exercise and a higher basic metabolic rate. More interesting is that BMI normalized by age in the postoperative period. By 12 months postoperative, BMI ranged narrowly from 31+6 for 60-70 patients to 32+6 for<30. The data suggests that weight loss success following PBD/DS favors youth and, conversely, is more difficult to achieve with increasing age, possibly related to increasing years with obesity.

Cardiovascular co-morbidities varied by age in the greatest number. Baseline rates of HTN, PHT, CHF, and angina increased with increasing age. These comorbidities continued to vary directly with age through 12 months post-op, a point at which BMI was clinically identical between age groups. While there are multiple pathophysiologic factors that mediate the development of cardiovascular dysfunction, obesity is a known major contributor. The data presented here suggests that one’s exposure time to obesity, the cumulative years during a lifetime spent carrying an elevated BMI, may impact the response to weight loss. This concept of “obesity years” implies that patients who have morbid obesity the longest
may not benefit from post-BPD/DS weight loss as do younger patients with shorter duration of obesity. Further studies are needed to examine specifically interaction between the cumulative timeframe that a patient had morbid obesity prior to undergoing bariatric surgery and subsequent outcomes postoperatively.

Pulmonary conditions did not show much variation when comparing the different age groups. OSA was the only co-morbidity shown to vary directly with age which could suggest that the longer exposure to obesity could lead to overall changes to a patient’s respiratory drive which is then unable to improve after weight loss. Michaud et al compared long term results of BPD-DS in patients with a mean age of 62 vs 40. Unlike our data, they found that resolution of OSA did not vary by age to a statistically significant degree. This difference could be due to the two age groups being closer in age (20 years) in rather than a 40-year difference between our youngest and oldest age groups.

Diabetes showed an interesting difference compared with the other co-morbidities that were examined in this study in that it resolved the most in the older population of patients. A 2009 meta-analysis by Buchwald et al. demonstrated a 95% resolution of type 2 diabetes in patients that underwent BPD/DS. They did not, however, breakdown the results by age group so comparison with the data in this study is difficult. Because the data does not take into account how long the patients have carried the diagnosis of type 2 diabetes for, as well as hemoglobin A1c, it is difficult to explain why the younger patients had less resolution of this co-morbidity post-operatively. Further investigation would be needed to explain this result.

Abdominal and hepatobiliary co-morbidities all were shown in our data to increased directly with increasing age. Abdominal hernias increased with age both pre-operatively and post-operatively. This is not surprising since increasing age has been shown to be a standalone factor in the development of hernias due to the weakening of the muscles of the abdominal wall as a person ages. Risk factors for the
development of cholelithiasis are obesity as well as weight loss. A possible explanation for why cholelithiasis increased with increasing age both pre-operatively could be, once again, the concept of obesity years, meaning that the older patients were obese longer which allowed for more time for development of gallstones when compared to younger patients who have been obese for less time. It is not unexpected that stress urinary incontinence increased with increasing age as it is a disease of the aging, often being attributed to causes such as anatomy and childbirth in women and prostate enlargement and surgery in men.

Older patients had significantly increased rates of both lower extremity edema and musculoskeletal pain both pre-and post-operatively. Lower extremity edema is commonly caused by venous insufficiency, heart failure, and pulmonary hypertension, all of which are diseases most commonly seen in the elderly, making it not surprising that the rates of edema increased with increasing age in our study. Kotowski et al. found that a potential mechanism for decreased pain following weight loss may be that a reduction of weight reduces the biomechanical stress on the load bearing joints, reducing pain responses. However, our data shows higher rates of MSK pain both pre and post operatively which could be due to the concept of obesity years as the long-term biomechanical stress caused by added weight could lead to irreversible changes that is not seen in patients that have been obese for shorter periods of time.

Psychological co-morbidities in obese patients did not vary by age pre-operatively or post-operatively. There were not enough patients who reported substance abuse for valid statistical analysis to take place. These results suggest that both younger and older patients have similar changes in their psychological symptoms after BDP/DS. Gulliford et al. found that bariatric surgery had a limited and short-lived impact on clinical depression, but they did not differentiate how it affected patients of different age groups. The data in our study suggests that the patients, regardless of age, had a similar response to depression after the weight loss operation.
Interestingly, angina, MS pain, LEE and SUI actually increase from baseline following BPD/DS in >60-year old patients. This could be contributed to several reasons including the fact that, as already mentioned, these are all co-morbidities seen in elderly patients more so than younger patients. Also, there potentially could be a loss to follow up of the patients that did not have these co-morbidities at baseline, leading to a skewing of the statistics.

**Limitations:**

This is one of the largest reported analysis of BPS/DS. However, there are some limitations in this investigation. Of course, the usual confounders of a retrospective study are present. The decreasing numbers of patients at progressive follow-up visits limited statistical power in the later observation periods. Information from each patient was self-reported by surgeons and staff at each SRC COEBS, which, even with 100% on-site validation by SRC clinical monitors, still could be a source of data variation. BOLD co-morbidity definitions used clinical and hospital laboratory definitions only, so they might not be as accurate as true pathologic observations. For example, liver biopsy was not a requirement for diagnosing liver disease. While length of exposure to morbid obesity may indeed correlate with increasing age, we did not have actual data on how long each patient had had obesity prior to BPD/DS. Finally, results of this study were limited to the super-obese BPD/DS patient population and, therefore, the findings might not reflect the effects of increasing age for other bariatric procedures.

**Conclusions:**

Among super-obese patients who undergo BPD/DS, pre-operative weight and BMI vary inversely to increasing age and are highest in the youngest age groups. However, in spite of lower pre-operative BMI
in older age groups, the incidence of serious obesity co-morbidities varied directly with age among BPD/DS patients. In addition, while BMI for all age groups at 12 months after BPD/DS was clinically identical, post-operative improvement in 12 weight-related medical derangements was inversely proportional to age. Only diabetes resolved more completely among older patients. Although BOLD did not record the duration of each patient’s obesity, these findings suggest the concept of “obesity years”, meaning that those who have obesity the longest accumulate more co-morbidities and are less likely to resolve them following BPD/DS than those who have obesity a shorter length of time. This advance knowledge may facilitate patient selection for BPD/DS, complementary to the surgeon’s clinical judgement. Data-informed planning and identification of optimal operative patients could yield superior BPD/DS outcomes.

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