Research Article
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Obesity years: clinical variation by age pre/post biliopancreatic diversion/duodenal switch (BPD/DS)

Abstract

Objective: To identify clinical variation by age, pre/post BPD/DS.

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 and continued through to 12 months post operatively. Gout varied directly and tobacco abuse inversely by age at baseline. The incidence of 12 of the 33 obesity-co-morbidities increased directly with age up to 12 months post operatively. In >60 patients, angina, MS pain, LEE and SUI increased from baseline after undergoing BPD/DS.

Conclusion: Despite 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.

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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.[1] Alhasoun et al found that age increased the risk of hypertension, heart failure, GERD, and musculoskeletal disorders.[2] The association between obesity and mortality risk becomes substantially stronger with age.[3] Elevated BMI has a profound impact on the body, increasing risk for musculoskeletal, cardiovascular, endocrine, and psychiatric diseases. Excess body weight accounted for approximately 4 million deaths in 2017, with 70% attributed to cardiovascular disease.[4] Bowman et al demonstrated that the incidence of diabetes and coronary heart disease in patients with obesity were increased for all ages and is associated with shorter overall survival.[5]

Bariatric surgery, including, Roux-en-Y gastric bypass, sleeve gastrectomy, and BPD/DS, is safe and effective in resolving comorbidities related to obesity in patients of all ages.[5] Pata et al demonstrated that, following BPD/DS, diabetes, HTN, triglycerides and cholesterol, improve significantly within one year.[6] Michaud et all found that BPD-DS resulted in resolution of obesity-related co-morbidities, but they did not stratify by age group.[7] Nevertheless, whether or not pre-operative clinical characteristics of patients with severe obesity undergoing BPD/DS vary directly by decade of age and the effect of increasing age on BPD/DS outcomes are unknown. The objective of this study was to identify variation by age groups pre-operatively and post-operatively in patients undergoing BPD/DS.

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 decade: <30(n=177), 30-40(n=456), 40-50(n=486), 50-60(n=407), 60-70(n=138), >70(n=9). For this type of study formal consent is not required.

Data included age, weight, BMI, and 31 weight-related 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 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.[8]

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. This variation in groups persisted at 2- and 6-month post op. 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.

Table 1 Weight, Weight loss, BMI after biliopancreatic diversion/Duodenal switch by age

	Age	Weight (kg) (SD)	Weight Loss (kg) (SD)	BMI (kg/m^2) (SD)
	<30	156.03+-35.91	NR	54.67+-10.48
5 Pre-Op	30-40	154.41+-32.99	NR	53.41+-9.22
	40-50	151.07+-34.89	NR	52.37+-9.56
	50-60	142.06+-28.36	NR	50.29+-9.33
	60-70	134.35+-27.08	NR	48.22i--8.37
	>70	131.73+-24.22	NR	44.83+-7.66
	p-value	0.04	NR	0.05
2	<30	13309+-31.03	20468+-10.18	47.01+-9.06
	30-40	134.3+-299.	21.14+-9.59	46.26+-8.59
	40-50	1290-+-299.7	20.81+-9.59	44.96+-8.60
	50-60	1212-+-248.4	20.3+-8.91	43.08+-8.34
	60-70	11675+-247.6	17.55+-7.21	41.91+-7.64
	>70	113+-23.1	18.73+-5.98	38.40+-7.31
	p-value	0.04	NR	0.05
6	<30	11 043+-26.46	44.69+-14.76	39.09+-8.02
	30-40	109.7+-273.	45.10+-13.85	37.94+-7.82
	40-50	1073-+-26.0.	43.88+-14.58	37.2+-7.59
	50-60	1020-+-22.0.	40.27+-13.02	36.35+-7.44
	60-70	10034+-2095.	35.9+-9.25	35.86+-6.32
	>70	95349+-229.8	33.56+-9.63	32.99+-7.49
	p-value	0.02	NR	0.03
12	<30	91677+-19.46	63.09+-19.28	32.02+-5.70
	30-40	8966+-22.2.	62.95+-17.77	30.98+-5.87
	40-50	9057+-23.1.	59.53+-18.37	31.65+-6.95
	50-60	8758+-2012.	54.48+-16.5	32.21+-6.74
	60-70	8547-+-16.6.	47.67+-13.38	30.88+-5.24
	>70	8945-+-1565.	48.53+-6.49	31.04+-5.91
	p-value	0.05	NR	
18	<30	82669+-15283	69.21+-21.81	29.4+-5.16
	30-40	88931+-24	69.92+-22.3	30.02+-6.98
	40-50	8779+-19.78	67.73+-19.78	30.06+-5.66
	50-60	8464-+-21.1.	61.92-+-19.51	29.48+-6.57
	60-70	8355-+-19.0.	51.26+-1 4.60	29.53+-5.53
	>70	92.2-+-30.5.	49.3+-18.9	32.88+-6.64

Citation: Gott ML, Osterdahl PR, Perry LD, et al. Obesity years: clinical variation by age pre/post biliopancreatic diversion/duodenal switch (BPD/DS). *Adv Obes Weight Manag Control.* 2021;11(4):103–113. DOI: 10.15406/aowmc.2021.11.00343

Table Continued...

	Age	Weight (kg) (SD)	Weight Loss (kg) (SD)	BMI (kg/m²) (SD)
24	p-value	0.04	NR	0.68
	<30	77578+-18.12	58.98+-16.331	28.50+-3.62
	30-40	8572-+-2209.	72.7+-20.04	29.54+-7.27
	40-50	8563-+-202.6	62.76+-28.86	28.86+-5.32
	50-60	8269-+-2121.	64.15+-20.23	28.36+-5.81
	60-70	83+-19.77	54.98+-16.49	29.57+-5.01
	>70	7247-+-1275.	44.26+-7.69	26.62+-0.04
	p-value	0.1	NR	0.93

Table 2 lists cardiopulmonary obesity comorbidities. Baseline and 2, 6, and 12 months after BPD/DS CHF, HTN, OSA, and angina varied directly with increasing age, from <30 to 60-70/>70. Pulmonary hypertension varied by age only at 12 months post-op. At 18 months, HTN and angina, impaired functional status, LEE, MS pain, SUI, were associated with increasing age. At 24 months post-BPD/DS rates of HTN and angina remained higher in older patients. Among patients >60 few cardiopulmonary co-morbidities improved after BPD/DS. Peripheral vascular disease, pulmonary hypertension, asthma, and obesity hypoventilation did not differ by age. Metabolic and endocrine co-morbidities are listed in Table 3. Diabetes mellitus and dyslipidemia affected older patients more 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 through 18 months.

Table 2 Cardio-pulmonary co-morbidities after biliopancreatic diversion/duodenal switch by age

Months	Age	CHF	PVD	PHT	Asthma	HTN	OSA	Angina	OHS
Pre-OP	<30	1.13%	0.56%	9.04%	26.55%	38.98%	41.24%	2.82%	2.26%
	30-40	1.75%	0.0241	0.1118	19.74% O	0.5	0.5592	1.54%	0.88%
	40-50	2.06%	2.26%	12.76%	23.87%	63.37%	65.23%	2.47%	2.88%
	50-60	8.35%	2.70%	13.27%	23.59%	80.10%	68.06%	5.90%	2.70%
	60-70	11.59%	3.62%	19.57%	24.64%	81.88%	63.77%	6.52%	1.45%
	>70	0.00%	12.82%	22.22%	33.33%	10.75%	77.78%	33.33%	0.00%
	p-value	<.0001	*05608	0.0804	0.4128	<.0001	<.0001	<.0001	*03065
2	<30	2.69%	0.00%	10.75%	21.51%	31.18%	38.17%	1.61%	2.15%
	30-40	3.15%	0.90%	9.66%	17.53%	40%	51.24%	0.67%	0.90%
	40-50	3.24%	2.16%	11.88%	18.79%	49.68%	56.80%	1.30%	1.94%
	50-60	9.44%	2.04%	13.52%	18.62%	67.60%	63.52%	4.59%	1.53%
	60-70	10.85%	2.33%	20.16%	22.48%	69.77%	59.69%	6.98%	1.55%
	>70	0.00%	0.00%	22.22%	22.22%	55.56%	77.78%	33.33%	0.00%
	p-value	<.0001	25.17%	0.033	0.7754	<.0001	<.0001	*<0001	*0.8057
6	<30	2.02%	0.00%	10.10%	22.23%	10.76%	32.32%	1.01%	2.02%
	30-40	2.96%	1.11%	9.63%	15.19%	9.66%	40.74%	0.74%	0.37%
	40-50	3.00%	1.00%	11.00%	20.00%	11.88%	46.00%	0.67%	1.67%
	50-60	8.73%	1.82%	9.45%	17.82%	13.52%	52.36%	5.09%	0.73%
	60-70	12.37%	2.06%	16.49%	21.65%	20.16%	53.61%	6.19%	2.06%
	>70	0.00%	0.00%	25.00%	25.00%	22.22%	62.50%	37.50%	0.00%
	p-value	0.0001	0.7295	0.3145	0.4443	0.033	0.0028	*<0001	*0.5402

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Table Continued...

Months	Age	CHF	PVD	PHT	Asthma	HTN	OSA	Angina	OHS
12	<30	1.96%	0.00%	9.80%	27.45%	29.29%	23.53%	0.00%	0.00%
	30-40	0.71%	0.00%	0.0709	14.18%	28.89%	26.95%	0.00%	0.71%
	40-50	2.87%	1.72%	8.62%	23.56%	36%	37.93%	0.57%	0.57%
	50-60	3.80%	1.63%	7.07%	15.76%	50%	38.04%	2.72%	0.00%
	60-70	17.19%	3.13%	18.75%	23.44%	65.98%	51.56%	9.38%	3.13%
	>70	0.00%	0.00%	40.00%	20.00%	37.50%	40%	40.00%	0.00%
	p-value	*<0001	45.57%	*0.0127	12.05%	<.0001	1%	*<0001	*0.173
18	<30	0.00%	0.00%	20.00%	40.00%	21.57%	30%	0.00%	0.00%
	0 30-40	0.00%	0.00%	10.20%	10.20%	22.70%	30.61	0.00%	0.0204
	0 40-50	3.03%	0.00%	6.06%	15.15%	26.44%	42.42%	0.00%	0.00%
	50-60	5.80%	0.00%	2.90%	10.14%	38.59%	36.23%	2.90%	0.00%
	60-70	0.1389	2.78%	11.11%	19.44%	51.56%	44.44%	8.33%	0.00%
	>70	0.00%	0.00%	0.25	0.25	0.6	0.75	0.5	0.00%
	p-value	*0.0625	*0.3554	*0.1973	*0.1506	*<0001	*0.4206	*<0001	*0.5798
24	<30	0.00%	NR	0.00%	14.29%	8 9.80%	14.29%	0.00%	NR
	30-40	0.00%	NR	0.00%	14.81%	7.09%	22.22%	0.00%	NR
	40-50	2.33%	NR	0.00%	6.98%	8.62%	0 25.58%	0.00%	NR
	50-60	0 8.00%	NR	4.00%	12.00%	0 7.07%	36.00%	4.00%	NR
	60-70	16.67%	NR	8.33%	16.67%	18.75%	50%	16.67%	NR
	>70	0.00%	NR	0.00%	0.00%	40.00%	50.00%	0.00%	NR
	p-value	*02225	*02225	*0.4435	*87.42%	*0.0127	*0.3627	*0.0538	NR

CHF, congestive heart failure; PVD, peripheral vascular disease; PHT, pulmonary hypertension; OSA, obstructive sleep apnea; OHS obesity yhypoventilation syndrome; NR not recorded; 25% cells have expected counts of <5

Table 3 Metabolic and endocrine comorbidities after biliopancreatic diversion/duodenal switch by age

Months	Age	Diabetes Mellitus	Gout	Dyslipidemia	Pseudotumor Cerebri
	<30	18%	3.39%	27.12%	2.82%
Pre-Op	30-40	31.80%	2.41%	28.07%	0.88%
	40-50	42.39%	4.53%	46.71%	1.65%
	50-60	5750%	5.65%	61.43%	1.47%
	60-70	59.42%	8.70%	65.22%	0.00%
	>70	66.67%	22.22%	44.44%	0.00%
	p-value	<.0001	0.0024	<.0001	*0.3141
2	<30	1452%	323%	23.12%	323%
	30-40	20.22%	7	73.82%	0,90%
	40-50	28.08%	5.40%	37.15%	1.04%
	50-60	33.16%	5.10%	48.98%	1%
	60-70	34.88%	6.98%	46.51%	0.00%
	>70	33.33%	22.22%	44.44%	0.00%
	p-value	<.0001	0.019	<.0001	*0.048

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Table Continued...

Months	Age	Diabetes Mellitus	Gout	Dyslipidemia	Pseudotumor Cerebri
6	<30	7.07%	4.04%	2020%	2.02%
	30-40	12.59%	1.85%	17.04%	0.00%
	40-50	18.00%	3.33%	26.67%	0.67%
	50-60	24.00%	6.18%	39.27%	0.36%
	60-70	27.84%	5.15%	39.18%	0.00%
	>70	12.50%	19.50%	3750%	0.00%
	p-value	<.0001	0.1158	<.0001	0.2154
12	<30	11.76%	1.96%	17.65%	0.00%
	30-40	4.96%	2.13%	6.38%	0.00%
	40-50	8.05%	3.45%	13.79%	1.20%
	50-60	10.87%	5.43%	25.54%	54%
	60-70	2656	4.69%	23.44%	0.00%
	>70	20.00%	20.00%	40,00%	0.00%
	p-value	0.0002	*0.2568	0.0001	*0.4311
18	<30	30.00%	0.00%	10,00%	0.00%
	30-40	8.16%	4.08%	8.16%	0.00%
	40-50	12.12%	3.03%	15.15%	152%
	50-60	13.04%	8.70%	15.94%	0.00%
	60-70	13.85%	2.78%	16.67%	0.00%
	>70	25.00%	50.00%	50.00%	0.00%
	p-value	*0.5222	*0.0024	*0.2985	*0.768
24	<30	42.86%	0.00%	42.86%	0.00%
	30-40	7.41%	7.41%	3.70%	0.00%
	40-50	2.33%		9.30%	2.33%
	50-60	8.00%	8.00%	16.00%	0.00%
	60-70	25.00%	0.00%	25.00%	0.00%
	>70	100%	0.00%	50.00%	0.00%
	p-value	*0.0072	*0.6923	*0.044	*0.8069

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 increased directly with increasing age. Abdominal panniculitis, GERD, and liver disease statistically differ at baseline. At 12 months GERD and liver disease occurred more in older patients. Stress urinary incontinence prevalence varied directly by age through 18 months.

Table 4 Abdominal and hepatobiliary comorbidities after biliopancreatic diversion/duodenal switch by age

Age	Cholelithiasis	Abdominal pannoculitis	GERD	Liver disease	Stress urinary incontinence	Abdominal hernia
<30	13.56%	18.08%	48.59%	3.39%	19.21%	3.39%
30-40	19.08%	19.74%	47.59% %	5.26%	30.70%	5.48%
40-50	23.66%	20.37% 1%	51.85%	4% 6.79% 9%	37.04%	11.11%
50-60	24.57%	21.13%	53.81%	8.35% %	39.07%	16.46%

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Age	Cholelithiasis	Abdominal pannoculitis	GERD	Liver disease	Stress urinary incontinence	Abdominal hernia
60-70	0.2681	24.64%	52.90%	0.0435	1% 52.17%	16.67%
>70	0.1111	0.111	0.2222	0	0.4444	0
	0.0127	0.7242	0.2133	0.1516	<.0001	<.0001
<30	22.58%	16.13%	42.47%		16.67%	
30-40	28.76%	16.63%	42.47% 6%	7.87%	26.52%	6.52%
40-50	34.13%	17.28%	45.36% %	10.80%	29.81%	9.72%
50-60	35.20%	16.58%	45.15%	11.99%	32.14%	14.29%
60-70	42.64%	14.73%	52.71%	10.08%	47.29%	13.18%
>70	44.44%	0.1111	0.3333	22.22%	0.4444	11.11%
p-value	0.0014	0.9826	0.3918	0.0435	<.0001	0.0002
<30	28.28%	17.17%	38.38%	5.05%	17.17%	
8% 30-40	35.56%	0.1963	37.04%	10.74%	21.11%	8.52%
40-50	39.67%	17.00%	42.00%	10.00%	25.00%	14%
50-60	39.27%	16.73%	43.64%	12.36%	26.55%	17.82%
%60-70	0.5464	19.59%	45.36%	9.28%	45.36%	16.49%
>70	0.625	0.125	25%	0.25	0.5	37.50%
p-value	0.0029	0.9291	0.4723	0.2846	<.0001	0.0002
<30	35.29%	23.53%	29.41%		19.61%	
30-40	40.43%	21.99%	24.82%	2.84%	17.02%	11.35%
40-50	45.98%	25.29%	36.78%	11.49%	19.54%	22.41%
50-60	45.11%	19.57% 0%	38.04%	13.04%	24.46%	26.63%
60-70	64.06%	34.38%	54.69%	9.38%	37.50%	45.31%
>70	0.8	0.4	0.4	0.4	0.6	60%
p-value	0.0108	0.2229	0.0021	*0.0027	0.0064	<.0001
<30		30.00%	40.00%	0	20.00%	40%
30-40	53.06%	18.37%	36.73%	6% 8.16%	24.49%	24.49%
40-50	56.06%	13.64%	33.33%	0% 13.64%	22.73%	37.88%
50-60	47.83%	17.39%	36.23%	8.70%	21.74%	36.23%
60-70	63.89%	16.67%	56.56%	8.33%	47.22%	38.89%
>70	50.00%	0	50.00%	25.00%	75.00%	0.5
p-value	*0.6411	*0.7546	*0.3494	*0.6155	*0.0156	*0.6373

Table Continued...

Age	Cholelithiasis	Abdominal pannoculitis	GERD	Liver disease	Stress urinary incontinence	Abdominal hernia
<30	0.2857	0.2857	0.4286	0	0.4286	0.1429
30-40	0.5185	0.2963	0.2222	0.037	0.1481	0.1481
40-50	0.5814	0.093	0.4186	0.1163	0.2326	0.2791
50-60	0.46	0.12	0.34	0.1	0.14	0.28
60-70	0.5	0.25	0.5	0.0833	0.4167	0.5833
>70	0.5	0	1	0	0.5	0.5
p-value	*0.7346	*0.1822	*0.1831	*0.8036	*0.1423	*0.1091

Somatic co-morbidities are presented in Table 5. Older patients had 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 in patients less than 60. Impaired functional status correlated directly with age pre-op and at 2- and 6-months post-op. Back pain did not change significantly.

Table 5 Somatica comorbidfties after biliopancreatic diversion/duodenal switch by age

Months	Age	BackPain	Impaired functaional Status	Lower Extremity Edema	Musculoskeletal Pain
	<30	59.32%	2.82%	34.46%	33.33%
	30-40	58.33%	1.97%	43.20%	44.52%
	40-50	60.91%	5.97%	45.06	52.47%
Pre-OP	50-60	61.43%	13.27%	56.27%	52.09%
	60-70	65.94%	15%	63.77%	68.84%
	>70	44.44%	22.22%	77.78%	77.78%
	p-Value	1%	<.0001	<.0001	<.0001
2	<30	51.08%	2.69%	30.11%	30.65%
	30-40	48.31%	2.25	35.73%	37.08%
	40-50	52.27%	5%	40.17%	46.65%
	50-60	51.53%	10.2%	44.13%	45.41%
	60-70	61.24%	13.18%	58.91%	65.89%
	>70	44.44%	22.22%	77.78%	77.78%
	p-Value	0%	<.0001	<.0001	<.0001
6	<30	40.40%	2.02%	30.30%	24.24%
	30-40	146.3%	2.96	30.74%	31.11%
	40-50	46.67%	4.33%	37.33%	40.33%
	50-60	42.18%	9.82%	39.64	40.%
	60-70	59.79%	15.46%	58.76	64.95%
	>70	37.50	12.50%	75.00%	87.5%
	p-Value	0.0602%	<.0001	<.0001	<.0001

Citation: Gott ML, Osterdahl PR, Perry LD, et al. Obesity years: clinical variation by age pre/post biliopancreatic diversion/duodenal switch (BPD/DS). *Adv Obes Weight Manag Control.* 2021;11(4):103–113. DOI: 10.15406/aowmc.2021.11.00343

Table Continued...

Months	Age	BackPain	Impaired functaional Status	Lower Extremity Edema	Musculoskeletal Pain
12	<30	43.14%	0.00%	33.33%	29.41%
	30-40	34.75%	1.42%	22.70%	21.28%
	40-50	40.80%	1.72%	37.36%	37.93%
	50-60	38.04%	8.15%	40.76%	38.59%
	60-70	62.50%	12.50%	60.94%	68.75%
	>70	60.00%	0.00%	80.00%	80.00%
	p-Value	0%	*0.0002	<.0001	<.0001
18	<30	40.00%	0.00%	50.00%	20.00%
	30-40	42.86%	0.00%	30.61%	26.53%
	40-50	42.42%	1.52%	39.39%	33.33%
	50-60	28.99%	11.59%	36.23%	36.23%
	60-70	47.22%	11.11%	58.33%	55.56%
	>70	75.00%	0.00%	100.00%	75.00%
	p-Value	*0.2481	*0.0266	*0.0194	*0.0379
24	<30	42.86%	14.29%	57.14%	28.57%
	30-40	22.22%	0.00%	18.52%	11.11%
	40-50	41.86%	0.00%	23.26%	30.23%
	50-60	42.00%	10.00%	40.00%	38.00%
	60-70	58.33%	8.33%	50.00%	58.33%
	>70	50.00%	0.00%	50.00%	100.00%
	p-Value	*0.3583	*0.1548	*0.1	*0.0141

Psychological and Behavioral co-morbidities are summarized in Table 6. Pre-operatively, tobacco use and depression varied inversely by age and the ages of 40-60 had the highest rates of depression and tobacco use, which decreased with increasing age. Mental health diagnosis and physiological impairment differed post-operatively only in the >70-year group at 24 months. Panniculitis, alcohol and substance abuse, asthma, obesity hypoventilation, PVD, back pain, mental health, depression, psychological impairment, pseudotumor cerebri, irregular menses, and DVT/PE did not vary by age.

Table 6 Psychological and behavioral comorbidities of after biliopancreatic diversion/duodenal switch y by age

Age	Mental Health Diagnosis	Support Group Attendance	Depression	Psychological Impairment	Tobacco Use	Substance Abuse	Alcohol Use
<30	7.91%	N/A	36.72%	12.43%	6.78%	1.69%	33.33%
30-40	12.28%	N/A	37.72%	15.00%	7.02%	0.88%	38.38%
40-50	14.4%	N/A	43.21%	18.72%	8.23%	0.41	33.74%
50-60	10.32%	N/A	44.23%	16.22%	3.93%	1.47%	34.4%
60-70	10.87%	N/A	2%35.51%	3%13.77%	2.17%	0.00%	26.81%
>70	11.11%	N/A	11.11%	11.11%	0.00%	0.00%	55.56%
p-value	0.2362	N/A	0.0515	0.3963	0.0323	*0.3672	0.1261

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Table Continued...

	Age	Mental Health Diagnosis	Support Group Attendance	Depression	Psychological Impairment	Tobacco Use	Substance Abuse	Alcohol Use
	<30	6.99%	23.12%	34.41%	10.75%	%6.45%	1.08%	25.81%
	30-40	11.46%	15.73%	32.36%	14.38%	4.49%	0.67%	18.99%
	40-50	13.17%	21.89%	38.23%	16.41%	6.70%	0.00%	26.35%
2	50-60	6211.00%	23.66%	42.09%	6315.00%	233.00%	721.00%	26.53%
	60-70	10.85%	2%19.38%	34.11%	11.63%	1.55%	0.00%	24.03%
	>70	11.11%	33.33%	0.00%	11.11%	0.00%	0.00%	44.44%
	p-value	0.3841	0.0535	0.0104	0.4765	0.0517	*0.2077	0.6787
	<30	8.08%	13.13%	27.27%	13.13%	8.08%	2.02%	24.24%
	30-40	13.70%	23.81%	31.11%	15.93%	7.04%	0.74%	28.52%
	40-50	14.00%	20.67%	34.33% %	17.00%	6.33%	0.00%	27.00%
6	50-60	4111.00%	3525.00%	441.45%	6515.00%	174.00%	772.00%	27.64%
	60-70	10.31%	19.59%	36.08%	12.37%	3.09%	0.00%	20.62%
	>70	12.50%	12.50%	12.50%	12.50%	0.00%	0.00%	50.00%
	p-value	0.5364	0.1916	0.0454	0.8799	0.29%	*0.0869	0.4267
	<30	9.80%	19.61%	31.37%	13.73%	7.84%	1.96%	31.37%
	30-40	15.60%	16.78%	34.04%	17.73%	7.09%	1.42%	36.17%
	40-50	12.64%	22.41%	32.76%	16.09%	8.05%	0.00%	27.59%
12	50-60	6411.96%	1622.28%	5442.39%	9916.3%	474.35%	692.17%	23.91%
	60-70	9.38%	18.75%	7%35.94%	12.50%	3.13%	1.56%	25.00%
	>70	20.00%	0.00%	0.00%	0.00%	0.00%	0%	60%
	0 p-value	4%0.7857	0.6377	0.1807	0.95%	*0.5584	*0.5938	0.1091
	<30	30.00%	10.00%	50.00%	30.00%	10.00%	0.00%	30.00%
	0 30-40	20.41% %	5%12.24%	34.69%	20.41%	8.16%	2.04%	24.49%
	40-50	12.12%	21.21%	30.30% %	16.67%	10.61%	0.00%	33.33%
18	50-60	5712.00%	7717.00%	736.23%	4816.00%	845.8%	382.9%	24.64%
	60-70	11.11%	0%16.67%	0%	13.89%	0.00%	2.78%	30.56%
	>70	25.00%	25.00%	0.00%	25.00%	0.00%	0.00%	50.00%
	p-value	*0.4446	*0.829	*0.4757	*0.8497	*0.7195	*0.8138	*0.7565
	<30	28.57%	14.29%	28.57%	28.57%	0.00%	0.00%	42.86%
	30-40	11.11%	18.52%	29.63%	14.81%	11.11% %	0.00%	51.85%
	40-50	18.60%	0%9.30%	46.51% %	25.58%	11.63% %	0.00%	34.88%
	50-60	10.00%	2918.00%	75732.00%	49718.00%	92.00%	382.00%	20.00%
	60-70	8.33%	25.00%	58.33%	8.73%	8.33%	0.00%	25.00%
	>70	100.00%	50.00%	50.00%	100.00%	0.00%	0.00%	50.00%
	p-value	*0.0123 0%	*0.5357	*0.3735	*0.062	*45.52%	*0.8717	*0.1017

25% of cells have expected counts of <5 0% *

Discussion

This study identified significant variation by age in the pre-operative clinical characteristics of 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, but by 18 months poat-operatively BMI was identical statistically in all ages. However, in spite of lower BMI with increasing age, cardiovascular co-morbidities varied directly by age at baseline and, adding pulmonary hypertension, post-operatively.

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Pre-operative diabetes varied directly with age but resolved to the greatest extent among >60 years patients. Incidences of abdominal hernia, cholelithiasis, and stress incontinence increased with age at baseline, and, with 12-month liver disease, also varied directly 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 in any age group. Our review of the literature indicates that these pre- and post-BPD/DS clinical variations by decade of age groups have not been reported previously and are important findings of this investigation.

Pre-operative weight and BMI were highest in the youngest patients in this study, as was post-BPD/DS weight loss. While super obesity in this study was defined as BMI>50, the >70 age group had a mean pre-operative BMI of 44 compared with higher starting BMIs found in the younger age groups.[9] The <30years group suffered the fewest somatic comorbidities, and lower rates of potentially disabling cardiopulmonary, endocrine/metabolic, and abdominal/hepatobiliary co-morbidities, possibly related to higher tolerance for cardiovascular exercise and a higher basic metabolic rate of youth. More interesting is that BMI normalized by age after BPD/DS. By 12 months postoperative, BMI ranged narrowly from 31+-6 for 60-70 patients to 32+-6 for<30. These results suggest 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 had the greatest association with increasing age. Baseline rates of HTN, PHT, CHF, and angina increased with increasing age. These comorbidities continued to be higher in older, 60-70/>70 patients through 12 months post-op, at which time BMI was identical among age groups. Obesity is a known major contributor to the development of cardiovascular dysfunction. The data here suggest that one's exposure time to obesity, the cumulative years spent carrying an elevated BMI, may impact the response to weight loss. From this one might speculate the concept of "obesity years" in which 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. Studies that capture the duration of obesity in individuals are needed to examine this specific interaction.

Pulmonary obesity co-morbidities varied little by age. Only OSA increased directly with age, suggesting that longer exposure to obesity could cause 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.[7] Unlike our data, they found that resolution of OSA did not vary by age. This difference could be due to the two age groups being closer in age (20 years) compared with the 40-year difference between our youngest and oldest age groups.

Diabetes differed interestingly 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 who underwent BPD/DS.[8] However, they did not break down the results by age group. Since the duration of type 2 diabetes preoperatively was not captured in BOLD, why younger patients resolved diabetes less dramatically than older individuals post-BPD/DS is not clear from the data.

Abdominal and hepatobiliary co-morbidities increased directly with increasing age. Abdominal hernias were associated with increased age both pre-operatively and post-operatively. This is not surprising since older age is a stand-alone factor for development of hernias due to weakening of the muscles of the abdominal wall.[10] While obesity and weight loss are linked to the incidence of cholelithiasis ocerall,[11] a possible explanation for the association between cholelithiasis and increased age both pre-operatively and after BPD/DS, again, could be the concept of obesity years, with older patients carrying excess weight years longer for development of gallstones, compared with younger patients affected by obesity for less time. It is not unexpected that stress urinary incontinence increased with increasing age as it is a disease of the aging, often attributed to causes such as anatomy and childbirth in women and prostate enlargement and surgery in men.[12]

Older patients had significantly increased rates of lower extremity edema and musculoskeletal pain both pre-BPD/DS and post-operatively. Causes of lower extremity edema include venous insufficiency, heart failure, and pulmonary hypertension, all of which are most commonly seen in the elderly, making it not surprising that the rates of edema increased with increasing age in our study.[13] Kotowski et al.,[14] found that a potential mechanism for decreased pain following weight loss may be that a reduction of weight reduces the biomechanical stress on load bearing joints, reducing pain responses.[14] However, persistently increased rates of MSK pain with increasing age in BPD/DS examined here patients could add somatic organs support for the concept of obesity years.

Psychological co-morbidities did not vary by age pre-operatively or post-operatively. Patients who reported substance abuse were too few for valid statistical analysis. These results suggest 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 impact on clinical depression but did not differentiate how it affected patients of different age groups.[15] Our data suggest that patients, regardless of age, had a similar response to depression following BPD/DS.

The BOLD database did not capture the number of years that each of the BPD/DS patients examined in the present study carried clinical obesity, so the length of exposure to excess body mass is not clear from the data. Nevertheless, from the statistically and clinically significant direct variation pre-BPD/DS and in outcomes reported here one might speculate that the cumulative years a person bears obesity may impact the response to weight loss. As such, those who have obesity the longest, defined in this paper as "obesity years", may not benefit as much from weight loss surgery as patients with a shorter duration of obesity co-morbidities. Schauer et al demonstrated, for instance, that length of time since diagnosis of diabetes is associated with a lower rate of diabetes resolution following bariatric surgery.[16] As obesity typically does not suddenly appear when one is 60 or 70 years old, it is likely that the older patients had obesity for a longer period of time and were unable to resolve their obesity related co morbidities as well as those that were younger.

There are limitations in this investigation, including the usual confounders of a retrospective study. The decreasing numbers of patients at follow-up visits limited statistical power in the later observation periods. Information was self-reported by medical professionals 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 laboratory definitions, which might not be as accurate as true pathologic

observations. While length of exposure to morbid obesity may indeed correlate with increasing age, data here did not capture how long each patient had obesity prior to BPD/DS. Finally, results of this study were limited to the 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, despite 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. Additionally, the association of clinical risks by age reported here is applicable to patients with obesity under the care all surgeons of all specialties, not only bariatric surgeons. The results of this study can be applied clinically to raise the index of suspicion for the risks of operation on older patients with severe obesity, leading to data-directed clinical evaluation and targeted pre- and post-operative preparation and intervention for improved outcomes.

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Conflicts of interest

The author declares that there are no conflicts of interest.

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