JOP. J Pancreas (Online) 2022 August 31; 23(8): 70-75.

ORIGINAL ARTICLE

Association between High Body Fat Percentage and Outcomes after Pancreaticoduodenectomy; Analysis of the NSQIP database

Sargun Virk[1], Sangrag Ganguli[2], Ye In Christopher Kwon[3], Saba Alvi[3], Muhammad Wasif Saif[4], and Hassan Aziz[5]*

[1]Division of Gastrosurgery, Department of Surgery, Dayanand Medical College, Ludhiana, India

[2]Department of Surgery, The George Washington University, School of Medicine and Health Sciences, Washington DC, United States

[3]Department of Surgery, Tufts Medical Center, Boston, MA, United States

[4]Orlando Health Cancer Institute, Orlando, FL, United States

[5]Department of Surgery, University of Iowa Hospitals and Clinics, Iowa City, IA, United States

ABSTRACT

Background There is literature showing an association between obesity and outcomes of pancreatic surgery. Obesity is mainly calculated by the use of the Body Mass Index. There are inherent flaws in using a simple BMI that takes into account only two variables. Our study aims to highlight the use of a Body Fat percentage calculator to predict obesity and its subsequent implications in outcomes after pancreaticoduodenectomy (PD). **Methods** A retrospective analysis of the 2019 NSQIP database was performed. First, patients were categorized into obese and Non-obese groups based on BF percentage. Then, we matched the two groups based on propensity score matching in a 1:1 ratio. The primary outcome measure was mortality. Secondary outcome measures were complications, including pancreatic fistula. **Results** After propensity score matching in a 1:1 ratio, there were 670 patients in the obese group and 670 in the non-obese group. Obese patients were more likely to have superficial surgical site infections (7% *vs.* 4.4%; p-0.04), and pulmonary embolism (3.4% *vs.* 0.2%; p-0.02), organ space surgical site infection (20.1% vs. 13.9%; p-0.002); rates of biochemical leaks (9.5% *vs.* 5%; p-0.001) and Grade B/C POPF (16.2% *vs.* 10.4%; p-0.001). There was no difference in mortality between the two groups (2.1% *vs.* 1.1%; p-0.1). **Conclusion** Percent body fat may help surgeons improve risk stratifications, project patient-reported functional outcomes, and better educate obese patients regarding postoperative expectations before undergoing pancreatic resections.

INTRODUCTION

Increasing obesity rates are a global concern. Data indicates that the number of obese people in the world has tripled since 1975, reaching approximately 2 [1]. One Billion people approximately 30% of the world's population -- and that the number is on the rise [1]. Prevalence of obesity has increased steadily among all US adults aged twenty or older. Between 2011 and 2014, roughly 36% of this population suffered from obesity, with a projected prevalence of 40% by 2025 [2,3]. As a result, surgeons are bound to encounter increasing numbers of patients with obesity undergoing Whipple procedures [4].

Received 08-Jul-2022 Manuscript No IPP-22-13841 **Editor Assigned** 11-Jul-2022 PreQC No IPP-22-13841(PQ) **Reviewed** 25-Jul-2022 QC No IPP-22-13841 **Revised** 08-Aug-2022 Manuscript No IPP-22-13841(R) **Published** 15-Aug-2022 DOI 10.35841/1590-8577-23.8.758

Keywords Pancreas, Pancreatitis, Obesity, Body fat, Outcomes, Pancreaticoduodenectomy, Pancreatojejunostomy, NSQIP
Correspondence Hassan Aziz
Department of Surgery
University of Iowa Hospital and Clinics
Iowa City, IA 52242, United States
E-mail hassan-aziz@uiowa.edu

The body mass index (BMI) is generally used to measure adiposity [4,5]. The duality of the BMI is that, while it is easy to use, it is limited to how accurate and pertinent the data obtained from it can be [5,6]. BMI uses only the weight and height to calculate the obesity of an individual. Individuals, such as bodybuilders, are overweight according to BMI but contain a low BF percentage. This highlights the fact that BMI does not consider the effect of age and gender on an individual's adiposity [7]. Research on body fat (BF) percentage has improved in recent years. BF percentage provides a better gauge of an individual's risk of weight-related diseases than BMI since BF percentage distinguishes fat from muscle [5]. BF percentage can therefore measure obesity better than BMI [8]. The American Council on Exercise defines obesity as men with 25% BF and women with 31% BF [9].

Although there have been a significant amount of studies that study the effect of obesity measured by use of

Citation: Aziz H. Association between High Body Fat Percentage and Outcomes after Pancreaticoduodenectomy; Analysis of the NSQIP database. JOP. J Pancreas. (2022) 23:758.

BMI on outcomes of pancreatic surgery. The link between pancreatic surgery outcomes and BF computed using several variables is not well defined. Using a large multi-institutional database, we want to emphasize the utility of a Body Fat Percentage Calculator to predict obesity and its subsequent role in postoperative morbidity and mortality after PD.

MATERIALS AND METHODS

The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database for the year 2019 and the associated procedure targeted databases for the pancreas were used in this study. The ACS-NSQIP is a nationally validated database including over 600 hospitals and more than 150 variables [9]. Patients who underwent a Whipple procedure were identified based on primary Current Procedural Terminology (CPT) codes: 48150 (Whipple-type procedure with pancreatojejunostomy), 48153 (Pylorus-sparing Whipple-type procedure with pancreatojejunostomy). Patients who underwent other pancreatic procedures, such as total pancreatectomy, distal pancreatectomy, and pancreatic enucleation or debridement, were excluded. Patients without information regarding either weight, height, age, or gender were also excluded.

Patients were categorized into Obese and Non-obese based on body fat percentage. BF was calculated using a formula by Deurenberg et al (1.20 x weight (kg) /height (m^2)) + (0.23 x Age) - 16.2 for men and (1.20 x (kg) / height(m2)) + (0.23 x Age) - 5.4 for women [10]. We defined obesity according to the American Council of Exercise, for men aged 20-60 as 35% and 30% in patients aged 61 and above. For women, obesity was defined as BF above 40% in women aged 20-60 and BF above 43% in women aged 61 and above. The primary outcome of interest was 30-day mortality. Secondary outcomes of interest were overall minor and major complications (30 days), clinically relevant postoperative pancreatic fistula (POPF) formation, surgical site infections (superficial and/or deep incisional and/or organ/space surgical site infections SSI), readmission rate during the first 30 days period, and prolonged postoperative length of stay.

We used the International Study Group of Pancreatic Surgery (ISGPS) grading system to define a postoperative pancreatic fistula [11]. POPF was defined as the presence of a postoperative pancreatic fistula and at least one of the following criteria: drain in place >21 days, hospital length of stay (LOS) > 13 days, organ space/surgical site infection (SSI), postoperative percutaneous drain placement, reoperation, sepsis or septic shock, renal failure requiring dialysis, or death. Our study defined prolonged length of stay (LOS) as the length of stay above the 75th percentile.

SPSS version 24 was used in this study to perform the statistical analysis (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.). Categorical variables were expressed using frequencies and proportions (%) and compared among groups using the Chi-Square test. Continuous variables were summarized with descriptive statistics such as means/ standard deviations (SDs) and medians/Interquartile range (IQR). Depending on the data distribution, either analysis of variance (ANOVA) or Kruskal-Wallis test was used to perform BMI Group comparisons of these variables. We also utilized propensity score matching in a 1:1 manner before comparing the two groups for differences in outcomes. Factors utilized for matching included: age, gender, race, preoperative weight loss, functional status, neoadjuvant therapy, comorbidities (COPD, heart failure, diabetes, hypertension), and functional status. We also matched operative findings, including operative time, need for blood transfusion, duct size, gland texture, drains, and venous reconstruction. An absolute standardized difference of <0.20 between treatment groups indicates good matching, with values of <0.10 considered ideal. An absolute standardized difference >0.20 indicated a severe imbalance and was unacceptable.

Multivariable Regression Analyses

The independent effect of body fat (categorized as obese or non-obese) and BMI >35 on outcomes was evaluated by multivariable regression. A logistic or linear regression model was constructed for each outcome that included both variables and adjusted for age, sex, and race as covariates. Effect sizes were summarized by odds ratios (OR) for the logistic regressions and standardized regression (beta) coefficients for linear regressions, and 95% confidence intervals (95% CI) for both. To weigh the relative importance of body fat versus BMI in predicting each outcome, the magnitudes of the beta coefficients/ORs were directly compared.

RESULTS

4,876 patients underwent pancreaticoduodenectomy during the study period after we excluded patients with missing data regarding the demographics, type of surgery, and specific outcomes. After propensity score matching in a 1:1 ratio, there were 670 patients in the obese group and 670 in the non-obese group. The two groups were similar in demographics, comorbidities, neoadjuvant therapy, and operative findings, including pancreatic duct size and gland texture. **Table 1** highlights the patients' clinicodemographic findings after propensity score matching. The two groups were similar in age, gender, comorbidities, and operative details.

Minor complications were seen more in obese patients (52.3% *vs.* 31.6%; p-0.01). Obese patients were more likely to have superficial surgical site infections (7% *vs.*

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4.4%; p-0.046) and pulmonary embolism (3.4% *vs.* 0.2%; p-0.02). **Table 2** highlights the minor complications.

Similarly, obese patients were more likely to have organ space surgical site infection (20.1% vs. 13.9%; p-0.002). **Table 3** highlights the major complications.

Specific complications related to pancreatic resections are highlighted in **Table 4**. There was no difference in mortality between the two groups (2.1% *vs.* 1.1%; p-0.1). There were higher readmission rates (18.5% *vs.* 16.4%; p-0.01) and prolonged LOS (4.3% *vs.* 2.8%; p.0.01) in the obese group. The rates of biochemical leaks (9.5% *vs.* 5%; p-0.001) and Grade B/C POPF (16.2% *vs.* 10.4%; p-0.001) were higher in the obese group. The incidence of complications (wound infections, PE, and PF) with increased BF is depicted in **Figure 1**.

Table 1. Demographics and Operative Characteristics after Propensity Score Matching.

Demographics	Nonobese (n=670)	Obese (n=670)	p - value
Age, y, mean (SD)	52.3 +/-13.4	52.5+/-14.1	0.8
	Sex, n (%)		0.6
Female	249 (37.2%)	257 (38.3%)	
Male	421 (62.8%)	413 (61.7%)	
Race, n (%)			0.9
White	404 (60.2%)	410 (61.1%)	
Black	66 (9.8%)	62 (9.2%)	
Asian	61 (9.1%)	58 (8.6%)	
American Indian or Alaska Native	3 (0.4%)	3 (0.4%)	
BMI	19.6 +/-5.4	29.8 =/-5.9	0
	Comorbidity, n (%)		
Severe COPD	25 (3.7%)	19 (2.8%)	0.3
CHF	1 (0.1%)	1 (0.1%)	1
Dialysis	2 (0.3%)	2 (0.3%)	1
Smoking	217 (32.3%)	223 (33.2%)	0.7
Hypertension	178 (26.5%)	170 (25.3%)	0.6
Diabetes	120 (17.9%)	116 (17.3%)	0.7
Obstructive jaundice	166 (24.7%)	156 (23.2%)	0.7
ASA class ≥ 3	471 (70.3%)	476 (71.0%)	0.7
Independent Functional Status	668 (99.7%)	670 (100%)	0.3
	Neoadjuvant Therapy		
Chemotherapy	146 (21.7%)	124 (18.5%)	0.3
Radiotherapy	59 (8.8%)	59 (8.8%)	1
	OR findings		
Mean OR Time, Mins	328.9 +/-145.6	328.5+/-149.2	0.9
Venous Reconstruction	99 (14.8%)	98 (14.6%)	0.9
Operative drain	580 (86.5%)	591 (88.2%)	0.4
	Gland texture, n (%)		0.3
Soft	187 (27.9%)	204 (30.4%)	
Intermediate	57 (8.5%)	46 (6.8%)	
Hard	180 (26.8%)	163 (24.3%)	
	Pancreatic Duct Size, n (%)		0.4
< 3 mm	159 (23.7%)	162 (24.1%)	
3- 6 mm	188 (28.0%)	177 (26.4%)	
> 6 mm	59 (8.8%)	46 (6.8%)	

Note CHF – Congestive heart failure, OR -operating room

Table 2. Minor Complications.

Outcomes, n (%)	Nonobese	Obese	p-value
Superficial surgical site infection	30 (4.4%)	47 (7.0%)	0.046
Pneumonia	27 (4.0%)	23 (3.4%)	0.5
Pulmonary embolism	2 (0.2%)	23 (3.4%)	0.02
Urinary tract infection	10 (1.5%)	7 (1.0%)	0.4
Bleeding requiring transfusion	118 (17.6%)	96 (14.3%)	0.1
Deep vein thrombosis	13 (1.9%)	17 (2.5%)	0.4
Sepsis	43 (6.4%)	58 (8.6%)	0.09

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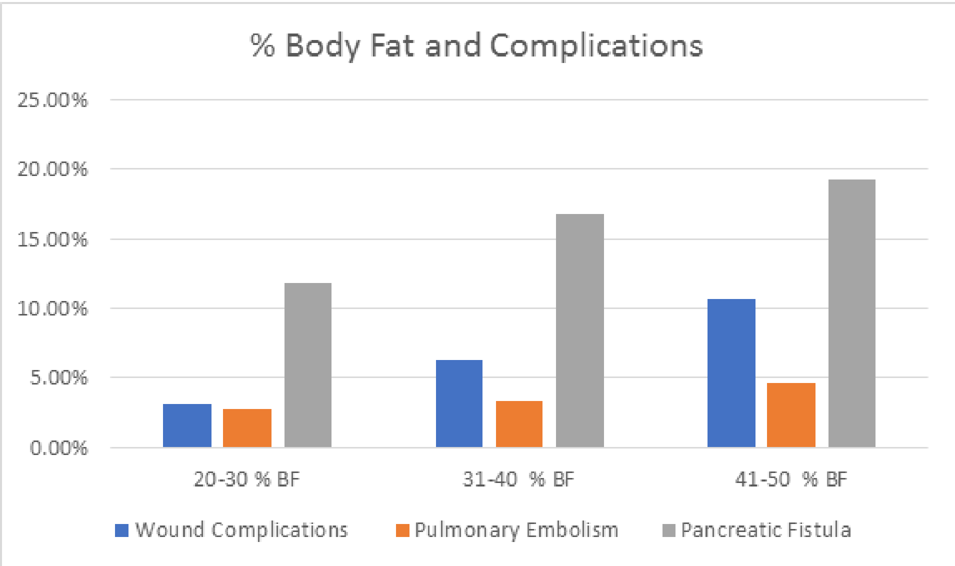
Table 3. Major Complications.

Major Complications, n (%)	Non-obese	Obese	p-value
Cardiac arrest	8 (1.2%)	4 (0.6%)	0.2
Myocardial infarction	6 (0.9%)	5 (7.4%)	0.7
Acute renal failure	4 (0.6%)	2 (0.3%)	0.4
Reintubation	18 (2.6%)	16 (2.3%)	0.7
Prolonged ventilation	13 (1.2%)	13 (1.2%)	1
Organ space surgical site infection	93 (13.9%)	135 (20.1%)	0.002

Table 4. Pancreas Specific Complications.

	Nonobese	Obese	p-value
	Complications, n (%)		
Mortality	8 (1.1%)	5 (2.1%)	0.1
Readmission	110 (16.4%)	124 (18.5%)	0.001
prolong LOS	19 (2.8%)	29 (4.3%)	0.01
Pancreatic fistula			0.001
biochemical leak only	34 (5.0%)	64 (9.5%)	
grade B and C	70 (10.4%)	109 (16.2%)	
Reoperation	32 (4.7%)	32 (4.7%)	1
Delayed Gastric Emptying	82 (12.2%)	85 (12.7%)	0.1



(p-<0.01)

Figure 1: Body Fat % and Outcomes.

Table 5. Multivariable Regression Analyses.

Outcome	Body Fat	BMI
Wound Infection/Organ Space infections	1.61 (0.70-3.77)	1.00 (0.94-1.06)
Pneumonia	3.15 (0.10-155.17)	0.92 (0.80-1.16)
Unplanned Intubation	0.77 (0.30-1.93)	1.04 (0.97-1.10)
Sepsis	0.30 (0.1-11.58)	1.13 (0.91-1.33)
Cardiac Arrest	2.13 (0.21-51.24)	1.02 (0.87-1.15)
DGE	1.27 (1.11-2.17)*	1.02 (1.01-1.03)*
POPF	1.36 (1.19-1.68)*	0.93 (0.73-1.19)*

Note: DGF – Delayed Gastric Emptying, POPF – Postoperative Pancreatic Fistula; * - Statistically Significant

Results for Multivariable Regression Analyses

Both increasing body fat and BMI were significantly associated with the risk of postoperative delayed gastric emptying (OR of 1.27 *vs.* 1.02), but the effect size was greater for body fat (0.57) as compared to BMI (0.40). In addition, the effect size of body fat on the risk of grades B and/or C postoperative pancreatic fistula was also greater than that of BMI (0.36 *vs.* 0.11). This holds true when

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directly comparing the magnitude of ORs for increased body fat and BMI on the risk of developing postoperative grade B and/or C pancreatic fistula (1.36 *vs.* 0.93). **Table 5** highlights the results of the Multivariable Regression Analyses.

DISCUSSION

The association between body fat and outcomes after PD is still unclear, and research in this domain is constantly evolving. However, our study highlights the adverse effects, higher readmission rates, and longer lengths of stay in patients with high BF composition. In addition, we found an association between pancreatic fistula and wound complications and high BF in patients undergoing PD.

The relationship between BF and surgical outcomes is not well studied; however, there is some general surgery literature on this issue. For example, in a study of 591 patients undergoing elective general surgical procedures, Waisbren et al. demonstrated that high BF was directly associated with a 5-fold increase in surgical site infections, with the risk of infections increasing as BF percentage increases [12]. In another study involving total joint arthroplasty, the authors found that percent BF was a better predictor than BMI for postoperative complications and patient-reported functional outcomes [13].

In this study, we chose percent BF as a marker for obesity. The association between BMI and outcomes after pancreatic surgery has been well-studied. The results, however, are conflicting. Some studies reported that obesity had been associated with unfavorable surgical outcomes such as longer operative times, more significant operative blood loss, and postoperative complications such as POPF [2]. However, other studies did not find significant differences in surgical outcomes and complications among patients who were obese and with normal-range BMI [14]. The impact of obesity on other features of elective surgery is also nebulous. For example, Benns et al. found that obesity had no impact on the operative time [3]. In another extensive analysis of 6336 patients undergoing general elective surgery, Dindo et al. revealed that obesity (defined by BMI) alone was not a predictor of adverse outcomes [6].

Moreover, the existing research has mainly focused on average weight and overweight-obese, with the most popular BMI cutoff of 25 [15,16]. Therefore, we chose BF as a marker for obesity and assessed any association between BF percentage and outcomes. The advantage here is that BF percentage distinguishes fat from muscle mass, making it a better proxy of obesity.

We found an increased risk of pancreatic fistula in the obese group, which is consistent with many other papers. First, different pancreatic textures could explain the above results in overweight patients and an increase in fat infiltration affecting the quality of the pancreatojejunostomy anastomosis in overweight patients [15]. Secondly, On many occasions, hard and atrophic pancreas are seen in patients with pancreatic cancer causing prolonged obstruction of PD. Finally, the third factor could be the increased complexity of the operation in obese patients.

Two recent NSQIP studies – Cheng et al. and Zorbas et al., have studied the relationship between obesity and outcomes after PD [3,16]. Our study is unique as it used BF as a marker for obesity and outcomes. Secondly, the study done by Change et al. was done with an older version of the NSQIP, which did not have pancreatic surgery-specific outcomes such as pancreatic fistula.

Body composition measurement methods are continuously being perfected. Ongoing efforts involve multisegmental and multifrequency bioelectrical impedance analysis, quantitative magnetic resonance for total body water, fat, lean tissue measurements, and further imaging to define ectopic fat depots [17,18,19,20,21]. Available techniques allow the measurement of fat, fat-free mass, bone mineral content, total body water, extracellular water, total adipose tissue, and its subdepots (visceral, subcutaneous, and intermuscular), skeletal muscle, selectively organs, and ectopic fat depots [15]. Although the techniques above may provide an accurate BF percentage; we calculated the BF value based on age, gender, height, and weight due to the lack of other data needed to calculate BF percentages from these other methodologies. However, there is growing literature of excellent correlation among different methods utilized for calculating BF [18].

It is important to consider the limitations of this study when interpreting its findings. The postoperative outcomes of the first 30 days are limited, as they lack information regarding mortality and other complications [22]. Additionally, the available data are predefined, and the disease's severity and stage are lacking. Patients with advanced malignant disease and weight loss from cancer cachexia could have been placed in a lower BMI category, lowering their postoperative mortality. Even though we utilized propensity score matching, there are factors that cannot be controlled for as they are not available in the database. Also, there were some variables with missing data, which is an important limitation of the study. Lastly, hospitals participate in NSQIP voluntarily and at their own expense, introducing some bias which likely includes larger hospitals [16].

CONCLUSION

In conclusion, percent body fat may help surgeons improve risk stratifications, project patient-reported functional outcomes, and better educate obese patients regarding postoperative expectations before undergoing pancreatic resections.

CONFLICT OF INTEREST

None

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FUNDING

None

DETAILS

Quick shot presentation at the American College of Surgeons, Clinical Congress Oct 2022.

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