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Bariatric surgery in patients with interstitial lung disease

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Abstract

Background Perioperative pulmonary complications are frequent in patients with interstitial lung diseases (ILD). Limited literature exists regarding the safety of bariatric procedures in patients with ILD. This study aims to assess the safety, feasibility, and outcomes of patients with ILD who underwent bariatric surgery at our institution.

Methods After IRB approval, all patients with preoperative diagnosis of ILD who had bariatric surgery at an academic center between 2004 and 2014 were retrospectively reviewed.

Results A total of 25 patients with ILD underwent bariatric surgery: Roux-en-Y gastric bypass ($n=17$, 68%), sleeve gastrectomy ($n=7$, 28%), and adjustable gastric banding ($n=1$, 4%). Twenty-one patients (84%) were females. The median age and preoperative body mass index (BMI) were 53 (IQR 42–58) years and 39 (IQR 37–44) kg/m^2, respectively. The median operative time and length of stay was 137 (IQR 110–187) min and 3 (IQR 2–5) days, respectively. The 30-day complications were reported in four patients (16%) but there was no pulmonary complication or unplanned admission to the intensive care unit. At 1-year follow-up (85%), the median BMI and excess weight loss were 30 (IQR 25–36) kg/m^2 and 67% (IQR 45–100), respectively. Compared to preoperative values, there was significant improvement in the pulmonary function test (PFT) variables at 1 year with respect to forced vital capacity (62% vs 74%; $n=13$, $p=0.003$), and diffusing capacity of the lungs for carbon monoxide (53% vs 66%; $n=10$, $p=0.003$). Six out of the seven potential lung transplant candidates became eligible for transplantation after weight loss, and one of them had successful lung transplant at 88 months after bariatric surgery.

Conclusion In our experience, bariatric patients with ILD achieved significant weight loss and improvement in PFT. Bariatric surgery in these higher risk ILD patients appears relatively safe with acceptable perioperative morbidity and improved candidacy for lung transplantation.

Keywords Bariatric surgery · Interstitial lung disease · Obesity · Weight loss · Pulmonary disease

The influence of obesity on normal respiratory physiology is complex and poorly understood [1]. Generally, patients with obesity have impaired lung function due to obesity-related alterations in respiratory physiology. Such alterations lead to an increase risk of pulmonary complications during anesthesia and after any major abdominal surgery, including bariatric procedures [2]. The rate of pulmonary complications after bariatric surgery generally ranges from 1 to 8% [2, 3].

Interstitial lung disease (ILD) is a broad term used to describe a complex set of pulmonary disorders that have similar clinical presentations, imaging findings, and histologic characteristics. Generally, ILD is characterized by inflammation and/or scarring of the interstitium of the lung parenchyma, leading to dyspnea, hypoxemia, and a restrictive ventilatory defect on pulmonary function testing (PFT). The diagnosis is based on clinical presentation in conjunction with radiologic investigation but sometimes requires an invasive biopsy [4].

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ILD is associated with high morbidity and mortality, especially in the idiopathic pulmonary fibrosis (IPF) group [4]. Prior studies have preliminarily investigated the rate of pulmonary complications in ILD patients. Published rates of pulmonary complications after lung resection or non-lung operations were 26% and 11%, respectively [4, 5]. Pneumonia and acute exacerbation of ILD were the most common postoperative complications in these patients. Patients undergoing lung resection, emergency surgery, and longer anesthesia time had a higher risk of postoperative pulmonary complication in this cohort [5].

In recent years, bariatric surgery has established itself as one of the most effective modalities for management of obesity and associated metabolic problems. Although morbidity and mortality rates would be expected to be higher in patients with pre-existing ILD, bariatric surgery may potentially improve pulmonary function in these patients through weight reduction. In addition, bariatric surgery may potentially improve lung transplant eligibility in patients who do not otherwise qualify due to excessive obesity. To our knowledge, limited literature exists with respect to the outcomes of bariatric surgery in patients with ILD. We hypothesize that bariatric surgery in patients with ILD may be relatively safe with acceptable perioperative morbidity and may improve lung function.

Materials and methods

After approval by our Institutional Review Board, a retrospective review of electronic medical records was completed to identify patients with preoperative diagnosis of ILDs who underwent bariatric surgery from February 2004 to December 2014 at an academic medical center. All patients with ILDs who received bariatric procedures including Roux-en-Y gastric bypass (RYGB), sleeve gastrectomy (SG), and adjustable gastric banding (AGB) were included. Patients without preoperative diagnosis of ILDs and those in whom no data were available were excluded. Patients with ILD were identified by searching for preoperative ICD 9 codes (515 and 516) and ICD 10 codes (J84).

After identification, the patient's clinical history, preoperative CT findings, and PFTs were independently reviewed by a pulmonologist specializing in ILD to verify the presence of ILD. CT scans were evaluated for reticular interstitial opacities, traction bronchiolectasis/bronchiectasis, and for the presence of honeycombing. PFT was evaluated for the presence of restriction or obstruction and to assess severity based on forced vital capacity (FVC) and total lung capacity (TLC), if available.

The primary endpoint for the study was defined as the perioperative ($\leq$ 30 day) pulmonary morbidity and admission to intensive care unit. Secondary endpoints for the study included all-cause perioperative morbidity, mortality, readmissions, reoperations, changes in weight, and PFT results at 1-year follow-up.

Study data were collected and managed using REDCap (Research Electronic Data Capture) hosted at our institution and customized for this study [6]. Collected data included baseline patient demographics, weight-related comorbidities (diabetes mellitus, hypertension, hyperlipidemia, gastroesophageal reflux disease, sleep apnea), history of chronic obstructive pulmonary disease (COPD), asthma, pulmonary hypertension, venous thromboembolism (VTE), chronic kidney disease, heart failure, fatty liver, and past history of abdominal procedures.

Data specific to ILD included specific ILD diagnosis [connective tissue disease (CTD)-related ILDs, IPF, sarcoidosis, chronic hypersensitivity pneumonitis, idiopathic non-specific interstitial pneumonia, and others], preoperative CT findings (honeycombing, reticular interstitial pattern, and traction bronchiectasis), PFTs [FVC, ratio of forced expiratory volume in 1 s to FVC (FEV1/FVC), percent predicted TLC, percent predicted volume (RV), and percent predicted diffusion lung capacity for carbon monoxide (DLCO)], 6-minute walk test (6MWT), and need for supplementary oxygen during 6MWT.

Perioperative variables included American Society of Anesthesiologist (ASA) score, procedures performed, duration, surgical approach, technique (laparoscopic, robotic, or converted to open), and operative time. In addition, intraoperative complications (significant bleeding > 250 ml, need for intraoperative transfusions, and conversion to open surgery), estimated intraoperative blood loss, and length of hospital stay were also noted.

Postoperative data constituted early postoperative complications (< 30 days). Postoperative complications were categorized as major complications and minor complications according to the ASMBS outcomes reporting standards [7]. Additionally, postoperative intensive care unit (ICU) stay and 30-day pulmonary complications (pulmonary edema, pleural effusion, COPD exacerbation, acute respiratory distress syndrome, atelectasis, respiratory failure requiring intubation or unplanned intubation and respiratory infections requiring antibiotics) were documented.

Data at 1 year included body mass index (BMI), percentage excess weight loss (EWL), percentage total weight loss (TWL), PFTs, 6MWT, and need for supplemental oxygen. Additionally, long-term data were collected with respect to eligibility for lung transplant and successful lung transplants performed if any. Continuous variables were summarized by medians with interquartile range (IQR) and categorical variables by counts and percentages. Wilcoxon rank sum test was utilized to compare paired continuous variables between two groups.

Results

Demographics

There were 5137 patients who underwent bariatric surgery during the study period. We identified 25 patients (0.49%) with preoperative diagnosis of ILDs among them. Twenty-one patients (84%) were female with median age and preoperative BMI of 53 years (IQR 42–58) and 39 kg/m^2 (IQR 37–44), respectively. Associated pertinent comorbidities included hypertension ($n=12$, 48%), sleep apnea ($n=10$, 40%), dyslipidemia ($n=12$, 48%), diabetes mellitus ($n=3$, 12%), gastroesophageal reflux disease ($n=16$, 64%), COPD ($n=3$, 12%), asthma ($n=10$, 40%), and VTE ($n=3$, 12%). Among the study cohort, 15 patients (60%) had a previous history of abdominal surgery.

Causes of ILDs included CTD-related ILD ($n=7$, 28%), IPF ($n=5$, 20%), sarcoidosis ($n=1$, 4%), chronic hypersensitivity pneumonitis ($n=2$, 8%), idiopathic non-specific interstitial pneumonia ($n=4$, 16%), and other causes ($n=6$, 24%). Preoperative PFTs included median FVC of 62% (IQR 51–79), FEV1/FVC of 101% (IQR 87–111), TLC of 65% (IQR 58–75), RV of 67% (IQR 62–73), and DLCO of 53% (IQR 38–64). Distance traveled during the preoperative 6MWT was at a median of 320 m (IQR 280–375) and 69% patients required supplementary oxygen during the test. Preoperative data are summarized in Tables 1 and 2.

Perioperative data

Perioperatively, ASA class constituted of class 2 ($n=3$, 12%), class 3 ($n=16$, 64%), and class 4 ($n=6$, 24%). Bariatric procedures performed included RYGB ($n=17$, 68%), SG ($n=7$, 28%), and AGB ($n=1$, 4%). Five patients insisted on their preferred procedure (four LSG and one AGB), and three patients had LSG because of excessive operative risk for RYGB. For the remainder, we deliberately chose a LRYGB to treat and prevent the development of GERD that is known to exacerbate ILD and lead to disease progression.

Surgical approach for most of the patients was laparoscopic ($n=23$, 92%), while one patient underwent robotic approach and the remaining one patient had conversion of laparoscopic approach to open. Two patients (8%) underwent revisional procedures. Median duration of procedure and estimated blood loss was 137 min (IQR 110–187) and 30 ml (IQR 30–50), respectively. There were no intraoperative complications. Pertinent perioperative data are summarized in Table 2.

30-Day postoperative outcomes

The median postoperative length of stay was 3 days (IQR 2–5). Early postoperative complications (< 30 days) were observed in four patients (16%) including anastomotic leak requiring reoperation ($n=1$), marginal ulcer ($n=1$), and anastomotic stricture requiring endoscopic dilatation ($n=2$). There was no 30-day pulmonary complication or unplanned admission to intensive care unit. Early postoperative outcomes are shown in Tables 2 and 3.

1-Year outcomes

At 1-year (follow-up rate of 85%), the median BMI, %EWL and %TWL were 30 kg/m^2 (IQR 25–36), 67% (IQR 45–100), and 22% (IQR 18–34), respectively. Postoperative PFTs were available in 13 patients (52%). Compared to preoperative values, there was significant improvement in the PFT variables at 1 year with respect to FVC (62% vs 74%; $n=13$, $p=0.003$), and DLCO (53% vs 66%; $n=10$, $p=0.003$). The % EWL among the 13 patients with available postoperative PFTs was comparatively higher at 93%. There was no mortality at 1-year follow-up. Six out of seven of the potential lung transplant candidates were eligible for transplantation after weight loss surgery, and one of them had successful lung transplant at 88 months after bariatric surgery. For the remaining five patients, three had significant improvement in pulmonary function and quality of life after the bariatric surgery such that transplant was no longer indicated, one international patient was lost to follow-up after being deemed eligible for transplantation, and another patient developed worsening of diffuse cutaneous systemic sclerosis that prevented her from being listed for transplantation. Pertinent 1-year outcomes are summarized in Table 4.

Discussion

The prevalence of ILD in our bariatric surgical patients over a 10-year period was quite low at 0.5%. There were no pulmonary complications or unplanned ICU admission during the perioperative period. The overall, all-cause morbidity during the early postoperative period was 16% without any mortality in this high-risk cohort. At 1 year follow-up, there was significant weight loss (67% EWL and 22% TWL) and improvement in PFTs (FVC:12%; $p=0.003$ and DLCO:13%; $p=0.003$). Six out of seven of the transplant candidates became eligible for lung transplant due to weight reduction and one patient successfully underwent lung transplantation.

ILD is well known for postoperative pulmonary complications, both in lung and non-lung surgeries [5]. Pulmonary complications after bariatric procedures have been reported to be 1–8% [2, 3]. Increasing age, BMI, operative time, ASA class, and presence of chronic respiratory disease are independently associated with increased risk of pulmonary complications following bariatric surgery. There are limited data available with respect to postoperative complications

Table 1 Preoperative characteristics of bariatric patients with ILD ($n=25$)

	% (n) or median (IQR)
Patients characteristics	
Age (year), median (IQR)	53 (42–58)
Sex, Female, % (n)	84 (21)
BMI (kg/m^2), median (IQR)	39 (37–44)
History of smoking > 10 pack years, % (n)	48 (12)
Specific ILD diagnosis, % (n)	
CTD related	28 (7)
Idiopathic pulmonary fibrosis	20 (5)
Sarcoidosis	4 (1)
Chronic hypersensitivity pneumonitis	8 (2)
Idiopathic non-specific interstitial pneumonia	16 (4)
Others	24 (6)
Preoperative CT scan findings, $n=22$	
Honeycombing, % (n)	14 (3)
Reticular interstitial patterns, % (n)	68 (15)
Traction Bronchiectasis, % (n)	41 (9)
Preoperative lung function test, median (IQR), (n)	
FVC (%)	62 (51–79), (21)
FEV1/FVC	101 (87–111), (17)
TLC (%)	65 (58–75), (8)
Residual lung volume (%)	67 (62–73), (8)
DLCO (%), median (IQR), n	53 (38–64), (16)
Distance traveled in 6MWT (m)	320 (280–375), (13)
Need for supplementary oxygen during 6MWT, % (n)	69 (9)
Comorbidities, % (n)	
Diabetes mellitus	12 (3)
Dyslipidemia	48 (12)
Hypertension	48 (12)
Obstructive sleep apnea	40 (10)
Gastroesophageal reflux disease	64 (16)
COPD	12 (3)
Asthma	40 (10)
Pulmonary hypertension	4 (1)
VTE	12 (3)
Chronic kidney disease	4 (1)
Heart failure	4 (1)
Fatty liver	12 (3)

% percentage, *n* patient count for the variable, *IQR* interquartile range, *BMI* body mass index, *ILD* interstitial lung disease, *CT* computed tomography, *FEV1/FVC* percent forced expiratory volume in 1 s to FVC, *DLCO* diffusing capacity of the lungs for carbon monoxide, *6MWT* 6-minute walk test, Others include Langerhans cell histiocytosis, post-inflammatory pulmonary fibrosis, and respiratory bronchiolitis

in patients with ILD after bariatric surgery. In our cohort, 30-day postoperative complications occurred in four patients but none were related to pulmonary complications, an unexpected finding. The relatively small sample size may have been insufficient to determine a reliable rate of pulmonary complications. Further, the laparoscopic, less invasive approach may have been contributory.

Morgan et al. [8] reported, in a multicenter population-based cohort study involving 12,062 patients, the incidence of ICU admissions post bariatric surgery to be 5%. For those requiring ICU admission, elective ICU admission and unplanned ICU admission were 69% and 31%, respectively. Unplanned ICU admissions in the early postoperative period were associated with open or revisional surgery, diabetes mellitus, chronic respiratory disease, chronic cardiovascular disease, and renal disease. In the present study, there were no elective or unplanned ICU admissions. The median length of stay was 3 days which is longer than the

Table 2 Perioperative outcomes of bariatric surgery in patients with ILD ($n=25$)

Perioperative outcomes	% (n) or median (IQR)
ASA class, % (n)	
I	0 (0)
II	12 (3)
III	64 (16)
IV	24 (6)
V	0 (0)
Surgical procedure, % (n)	
SG	28 (7)
RYGB	68 (17)
Gastric banding	4 (1)
Revisional procedures, % (n)	8 (2)
Surgical technique, % (n)	
Laparoscopy	92 (23)
Robotic	4 (1)
Laparoscopic converted to open	4 (1)
Operative time (min), median (IQR), (n)	137 (110–187), (21)
Estimated blood loss (ml), median (IQR), (n)	30 (30–50), (21)
Length of stay (days), median (IQR)	3 (2–5)
Postoperative ICU stay, % (n)	0
30-day complications, % (n)	16 (4)
Pulmonary complications	0
Anastomotic leak	4 (1)
Marginal ulcer	4 (1)
Anastomotic stricture	8 (2)
Reoperations, % (n)	4 (1)
Readmissions, % (n)	0
Mortality, % (n)	0

ASA American Society of Anesthesiology, *ICU* intensive care unit

median LOS reported for contemporary bariatric surgery. This may be attributed to several factors. First, during the study period, fast-track recovery after surgery protocols was not yet established at our institution. Also, the fact that our patients' population had higher rates of risk factors known to increase length of stay, such as diabetes mellitus, hypertension, GERD, pulmonary hypertension, chronic kidney disease, and heart failure, made surgeons more cautious regarding discharge and might have contributed to longer hospital stays. Even though there were no ICU admissions or pulmonary complications, patients with lung disease can have increased length of stay due to hypoxemia events and desaturation. The overall favorable perioperative outcomes in our limited cohort might have been a result of the multidisciplinary team approach involving bariatric surgeons, pulmonologists, anesthesiologist, radiologist, psychologist, and dietician.

Although lung transplantation may be the most effective treatment for ILD, many patients may not qualify due to severe obesity. Patients with ILD may be prone to obesity due to chronic steroids and inability to exercise (dyspnea, arthritis, excessive hypoxemia, other comorbidities). According to the guidelines for lung transplantation, patients with BMI > 35 kg/m^2 are not eligible for lung transplant despite the severity of the lung disease [9]. Increased waiting period for ILD patients with severe obesity and resultant disease progression may also contribute to worsening of post-transplant outcomes [10]. When weight is a key barrier to transplant, bariatric surgery may be a viable option. Bariatric surgery has been shown to result in excellent and sustainable weight loss in the range of 10–30% body weight loss at 5–12 years [11, 12]. In our cohort, at 1 year post bariatric surgery, the median BMI, %EWL, and %TWL were 30 kg/m^2, 67%, and 22%, respectively. Six out of seven of the transplant candidates were eligible for lung transplant (BMI < 35 kg/m^2) and one patient had successful lung transplantation after the weight loss surgery. Hence, bariatric surgery can be considered as a bridging treatment for end-stage lung disease with obesity to improve their eligibility for lung transplantation.

Obesity promotes structural changes in the thoracoabdominal region that leads to limited diaphragm and rib movement, plus a pro-inflammatory reaction of the airway [1, 13–15]. A systematic review of the literature has concluded that obesity causes a decrease of FEV1, FVC, and TLC suggesting a restrictive respiratory pattern associated with obesity [13]. Bariatric surgery has been shown to improve PFTs. A recent meta-analysis involving 23 studies (1013 participants) showed that pulmonary function scores were significantly improved after bariatric surgery [16]. The merging results from all 23 studies showed a significant improvement of the overall dynamic lung volume tests (FVC and FEV1) after bariatric surgery. DLCO did not show significant improvement after bariatric surgery [17, 18]. In the present study, we found improvement in the PFTs and 6MWT at 1 year after bariatric surgery. There was also significant improvement in the FVC (62% vs 74%; $p=0.003$) and DLCO (53% vs 66%; $p=0.003$). The significant decrease in BMI after bariatric surgery was likely a major factor in improvement of pulmonary compliance and breathing effort.

This study does have several limitations. This is a retrospective study in a single-referral center with a small sample size and short follow-up time. The patient population was heterogeneous, and no study groups were compared. There were 48% of missing data on PFTs and 6MWT during the follow-up. No postoperative PFTs testing was conducted on some of the patients and for others these data were not available (not retrievable from other institutions, improved symptoms not requiring testing, etc.). This is a clear limitation of the study attributed to its retrospective

Table 3 Perioperative outcomes stratify by type of bariatric surgery in patients with ILD ($n=25$)

Perioperative outcomes	SG ($n=7$)	RYGB ($n=17$)	Gastric banding ($n=1$)
Revisional procedures, % (*n*)	0	13 (2)	0
Surgical technique, % (*n*)			
Laparoscopy	100 (7)	88 (15)	100 (1)
Robotic	0	6 (1)	0
Laparoscopic converted to open	0	6 (1)	0
Operative time (min), median (IQR), (*n*)	123 (79–168), (6)	143 (125–190), (15)	
Estimated blood loss (ml), median (IQR), (*n*)	40 (26–50), (6)	30 (30–50), (15)	
Length of stay (days), median (IQR)	4 (2–6)	3 (2–6)	2
Postoperative ICU stay, % (*n*)	0	0	0
30-day complications, % (*n*)	0	24 (4)	0
Pulmonary complications	0	0	0
Anastomotic leak	0	6 (1)	0
Marginal ulcer	0	6 (1)	0
Anastomotic stricture	0	12 (2)	0
Reoperations, % (*n*)	0	6 (1)	0
Readmissions, % (*n*)	0	0	0
Mortality, % (*n*)	0	0	0

ASA American Society of Anesthesiology, *ICU* intensive care unit

Table 4 1-year follow-up of PFTs after bariatric surgery

Patient characteristics	Preoperative	1 year postoperatively
BMI (kg/m^2), median (IQR), (*n*)	53 (37–44), (25)	30 (25–36), (22)
Percent EWL, median (IQR), (*n*)		67 (45–102), (22)
Percent TWL, median (IQR), (*n*)		22 (18–34), (22)
FVC (%), median (IQR), (*n*)	62 (51–79), (21)	74 (61–87), (13)
FEV1/FVC, median (IQR), (*n*)	101 (87–108), (17)	98 (95–109), (11)
TLC (%), median (IQR), (*n*)	65 (58–75), (8)	109 (101–118), (3)
Residual lung volume (%), median (IQR), (*n*)	67 (62–73), (8)	101 (93–103), (3)
DLCO (%), median (IQR), (*n*)	53 (38–64), (16)	66 (43–81), (10)
Distance traveled in 6MWT (m), median (IQR), (*n*)	320 (280–375), (13)	448 (430–468), (5)
Need for supplemental oxygen during 6MWT, *n/N*	9/13	1/5

BMI body mass index, *IQR* interquartile range, *n* patient count for the variable, *EWL* excess weight loss, *TWL* total weight loss, *FEV1%F* percent forced expiratory volume in 1 s to FVC, *DLCO* diffusing capacity of the lungs for carbon monoxide, *6MWT* 6-minute walk test, *N* number of patients available for the variable, % percentage

nature. Prospective studies including specific pulmonary function data are certainly a necessity.

Conclusion

Our study suggests that carefully selected patients with interstitial lung disease and severe obesity may benefit from bariatric surgery by improved pulmonary function as a result of significant weight loss. Overall complications in these patients seem to be reasonable considering their increased risk. Bariatric surgery may also enable patients with severe obesity to qualify for lung transplantation. These initial results warrant further assessment of bariatric surgery in patients with ILD and severe obesity.

Compliance with ethical standards

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