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BRIEF COMMUNICATION

Prediction of Airflow Obstruction and the Risk of Complications in Morbidly Obese Patients Undergoing Bariatric Surgery

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Abstract

Morbidly obese subjects with airflow obstruction who underwent laparoscopic bariatric surgery appear to have the greatest risk to develop complications. In a retrospective cohort study, we identified a waist circumference ≥ 120 cm, smoking history ≥5PY and history of obstructive lung disease as statistically significant predictors of airflow obstruction. The resulting algorithm, aimed to identify subjects with airflow obstruction before bariatric surgery, was validated in a prospective study. The algorithm was found to be effective in identifying patients with low risk of airflow obstruction (negative predictive value 94.7%). Airflow obstruction, however, was not associated with post-operative complications as we expected. In contrast, inspiratory capacity and the Epworth Sleepiness scale were more promising predictors for post-operative complications in subjects undergoing bariatric surgery.

Keywords Obesity · Lung function · Bariatric surgery · Complications

Introduction

Bariatric surgery is the only longstanding effective treatment of morbid obesity. However, patients undergoing bariatric surgery may develop post-operative complications. Pulmonary complications such as pneumonia and respiratory failure account for one-fifth of the morbidity after bariatric surgery [1]. Hamoui et al. demonstrated that vital capacity was independently predictive of post-operative complications and they concluded that pre-operative pulmonary function testing is useful to predict complications of bariatric surgery through open laparotomy [2]. We previously demonstrated that subjects with obstructive pulmonary function had a threefold risk of complications after laparoscopic bariatric surgery [3]. This underlines that pre-operative pulmonary function testing might also be useful to assess a patient's post-operative

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complication risk. With the increasing number of laparoscopic bariatric procedures, it is important to determine whether a pre-operative lung function is necessary in every patient. A screening algorithm to identify patients with high risk of obstructive lung function and complications will be useful in the clinic to select those who should perform a pre-operative lung function test. The present study had two aims: (1) to develop a screening algorithm for prediction of obstructive lung function and (2) to validate this algorithm in morbidly obese patients undergoing bariatric surgery.

Methods

This study consisted of a retrospective part and a prospective part. The aim of the retrospective study was to develop a screening algorithm. The aim of the prospective part was to validate this algorithm in patients who underwent a pre-operative screening program for bariatric surgery in the Franciscus Gasthuis in Rotterdam, the Netherlands. Eligibility criteria for bariatric surgery, assessments during this study and the details about the bariatric surgery are shown in supplemental file (S1). All participating subjects gave informed consent. This study was approved by the local medical research ethics committee (Toetsingscommissie Wetenschappelijk Onderzoek Rotterdam e.o; protocol 2013/17).

Methods and Statistics Retrospective Cohort

In the retrospective part, patients were included between October 2009 and March 2012. Data from a previous study was used for developing a screening algorithm in this study [3]. All subjects performed spirometry and were seen by a pulmonologist before admission to bariatric surgery. The primary endpoint was a significant obstructive lung function (either FEV_1 increase after salbutamol 400 μg of ≥ 12% and 200 ml or FEV_1/FVC ratio < 0.7) with a need for medication (inhalation corticosteroid (ICS with or without short-acting or long-acting β-agonists (SABA or LABA)) prescription.

Patients were divided into groups with and without medication prescription after consultation. Unadjusted between-group comparisons were performed using Student's *t* test or the chi-square test and the Mann-Whitney *U* test for non-parametric comparisons. Multiple logistic regression analysis (stepwise backward procedure) was used to assess the relationship between pre-operative factors and the risk of medication prescription adjusted for other co-variables. Baseline variables associated with complications in univariate analysis were examined in the logistic regression analysis. Age and gender were added to the regression analysis. All analyses were performed using SPSS 18.0 software (SPSS Inc., Chicago, Illinois, USA). A two-sided $p < 0.05$ was considered a statistically significant result.

Methods and Statistics Prospective Cohort

Between April 2015 and December 2017, we performed a longitudinal cohort study comprising candidates for laparoscopic bariatric surgery. All subjects were screened with the 1-1-2 screening algorithm (1 point for waist circumference ≥ 120 cm, 1 point for smoking history ≥5PY and 2 points for a history of obstructive lung disease). A cut-off point of 2 was used to identify subjects with a low risk of obstructive lung function (< 2) and subjects with a high risk of obstructive lung function (≥ 2). All subjects performed spirometry. Patients were contacted by telephone after 7 and 30 days after bariatric surgery and post-operative complications were scored with a standardized question form. In addition, medical records of patients were screened for complications. Complications were divided into pulmonary, surgical, infectious, or other complications.

Sensitivity and specificity were calculated for obstructive lung function. Primary outcome was the negative predictive value (NPV) of the 1-1-2 prediction score for obstructive lung function. NPV > = 0.87 was considered as valid to use the algorithm as a predictive triage test. To assess which baseline values were associated with complications, baseline values were compared between subjects with and without complications with Student's *t* test or the chi-square test and the Mann-Whitney *U* test for non-parametric comparisons. In the subgroup with a 1-1-2 score ≥ 2, a multiple logistic regression analysis (backward) was used to assess the relationship between pre-operative factors and the risk of complications adjusted for other co-variables. Baseline variables associated with complications in univariate analysis were examined in the logistic regression analysis.

Results

Retrospective Cohort

A total of 769 patients was included (mean BMI 45.4 kg/m2, M:F 1:4). In 105 patients (13.7%), medication was prescribed before bariatric surgery after consultation with the pulmonologist. Baseline characteristics showed that subjects with medication prescription (ICS with or without SABA or LABA) were older (40.6 vs. 42.4 years, $p = 0.012$), had a larger abdominal circumference (131.3 vs. 135.2 cm, $p = 0.028$) and more pack years (8.1 vs. 12.4 years, $p = 0.012$). Furthermore, they more often had a history of asthma or COPD (14.4 vs. 49.5%, $p < 0.001$), and were already using inhalation medication (17.4 vs. 47.6%, $p < 0.001$).

Regression Analysis

After adjustment for age, gender, and the use of inhalation medication, it was shown that an abdominal circumference of > 120 cm (OR 2.6), > 5 pack years smoking (OR 1.9), and the history of asthma or COPD (OR 5.5) were significant predictors for a significant airflow obstruction requiring inhaler medication. From these parameters, a predictive 1-1-2 algorithm was deducted giving 1 point for an abdominal circumference of > 120 cm, 1 point for > 5 pack years of smoking, and 2 points for a history of asthma or COPD. The area under the curve was 0.728. A cutoff point of 2 gave a sensitivity of 0.702 and a specificity of 0.658.

Results Prospective Cohort

A total of 250 patients were included of whom 152 subjects had a 1-1-2 algorithm score < 2 (61%) and 98 subjects ≥2 (39%). The 1-1-2 algorithm provided a NPV of 94.7% for prediction of obstructive lung function, which was considered as valid. Prognostic accuracy was 64.7%, sensitivity 68.0%, and specificity 64.3% for airflow obstruction. Prognostic accuracy of 1-1-2 algorithm was 46.2%, sensitivity 35.9%, and specificity 57.4% for all peri-operative complications.

Table 1 Post-operative complications

	Frequency
Pulmonary complications	9 (4.6%)
• Respiratory tract infection	7
• Asthma/COPD exacerbation	2
Surgical complications	15 (7.7%)
• Hematoma (intra-abdominal)*	7
• Active bleeding (intra-abdominal)****	4
• Spleen injury*	1
• Anastomotic leak**	2
• Stenosis*	1
Infectious complications	14 (7.2%)
• Urinary tract infection	2
• Wound/abdominal wall infection	8
• Infected hematoma*	1
• Phlebitis	1
• Gastro-intestinal infection*	1
• Unknown	1
Other complications	16 (8.2%)
• Deep venous thrombosis	1
• Post-operative abdominal pain	6
• Dysphagia	1
• Dehydration	3
• Hypotension	2
• Hypertension	1
• Constipation*	1
• Arterial occlusion*	1

*Complications that resulted in re-admission in hospital

Complications could be assessed in 195 patients (78.3%). Fifty-four patients could not be contacted by telephone. There were in total 54 complications in 52 patients (27.7%) until 30 days after bariatric surgery: 15 surgical (7.7%), 14 infectious (7.2%), 9 pulmonary (4.6%), and 16 other complications (8.2%) (Table 1).

There were 13 re-admissions (6.7%) (Table 1). Re-laparoscopy was performed in 1 patient, re-laparotomy was performed in 3 patients (hematoma (1×), active bleeding (2×)), and echo-guided puncture of an abscess in 1 patient. There were no fatal complications.

Patients with complications had a lower mean FEV_1 (89% vs 93.5%, $p = 0.049$), a lower vital capacity (VC) (99% vs 104%, $p = 0.027$), and a lower inspiratory capacity (IC) (115% vs 124%, $p = 0.037$) (Tables 2 and 3). Despite the lower FEV_1 in patients with complications, the sensitivity of obstructive lung function (FEV1/FVC < 0.70 and/or Δ FEV1 12% + 200 cc) for total complications as well as pulmonary complications was low (sensitivity 7.8% (AUC 0.553) and 7.9% (AUC 0.555) respectively). Interestingly, subjects with complications had a trend for a higher score on Epworth Sleepiness Scale (ESS), suggesting a higher occurrence of OSAS in the group with complications (Table 2).

After logistic regression analysis, adjusting for age, gender and BMI, not airway obstruction, but IC (OR 0.91) and ESS (OR 1.5) remained significant predictors of total post-operative complications (AUC 0.796). For pulmonary complications, only ESS remained a significant predictor (OR 1.5).

Discussion

In the present study, we aimed to develop a screening tool to predict airway obstruction in morbidly obese subjects undergoing bariatric surgery. With a high negative predictive value, the 1-1-2 algorithm appeared to be useful to rule out patients with low risk of obstructive lung function. However, in the prospective analysis, we have shown that an obstructive lung function is not associated with more post-operative complications in morbidly obese subjects. With the introduction of laparoscopic bariatric surgery, the rate of pulmonary complications is significantly lower as shown by Masoomi et al. They demonstrated that the greatest rate of acute respiratory failure was observed after open gastric bypass surgery, and that this rate was much lower after laparoscopic bariatric surgery [4]. In the present study, we have shown that the rate of pulmonary complications was the lowest compared with other complications and there were no cases of respiratory failure. This may be due to improved anesthesia techniques and

Table 2 Baseline characteristics of patients with and without complications

	Patients with complications (*n* = 52)	Patients without complications (*n* = 143)	*p* value
Age (years)	43.7 ± 9.8	40.6 ± 11.6	0.092
Weight (kg)	122.2 ± 17.3	124.3 ± 17.7	0.459
BMI (kg/m2)	42.0 ± 4.6	43.4 ± 4.8	0.074
Waist circumference (cm)	126.7 ± 11.8	129.9 ± 13.0	0.121
Gender (% female)	82.7	82.5	0.977
Smoking status			
Never (%)	36.5	40.6	0.758
Former (%)	38.5	39.2	
Active (%)	25.0	20.2	
Comorbidity			
Diabetes mellitus (%)	11.5	14.8	0.574
Hypertension (%)	34.6	25.2	0.193
Hypercholesterolemia (%)	23.1	14.0	0.130
Asthma (%)	9.6	10.5	0.859
COPD (%0	1.9	0.7	0.453
ACQ (median)	0.0 (0.0–0.5)	0.0 (0.0–0.33)	0.292
AQLQ (median)	6.6 (6.1–7.0)	6.8 (6.3–7.0)	0.342
ESS (median)	3.0 (1.0–7.0)	2.0 (1.0–4.0)	0.075
GERDQ (median)	6.0 (6.0–7.0)	6.0 (6.0–7.0)	0.776
Surgery			
ASA (median)	3.0 (3.0–3.0)	3.0 (3.0–3.0)	0.603
Operation (% gastric bypass)	67.3	58.0	0.242
Operation duration (min)	60.8 ± 20.0	59.1 ± 20.5	0.615
Admission duration (hours)	28 (26–52)	27 (26–28.5)	0.013

increased experience with laparoscopic techniques by surgeons. In addition, post-operative complications may be reduced effectively by the standardized pre- and post-operative care of bariatric patients, such as adequate analgesia, early mobilization of patients from bed, the use of low-molecular weight heparin to prevent trombo-embolic events, and use of proton pump inhibitors. However, compared with other studies in this field, the rate of pulmonary complications and total complications in the present study may seem high. For example, in a prospective study of 1055 patients who underwent elective non-thoracic surgery, the rate of pulmonary complications was 2.7% within 7 days of surgery [5]. In contrast to our study, the included patients were not particularly obese and the complications included respiratory failure, pneumonia, and atelectasis. In our study, the mean BMI was above 40 kg/m^2, but the pulmonary complications were mild and did not result in hospital admission. In a review about prediction of post-operative pulmonary complications in patients undergoing non-thoracic surgery, the incidence of pulmonary complications varied from 2 to 19%. This variation could be the result of different definitions for pulmonary complications. Furthermore, hypercapnia and reduced spirometry values were not associated with post-operative pulmonary complications in this review [6]. In another study in obese patients

Table 3 Pulmonary function tests

	Patients with complications	Patients without complications	*p* value
FEV_1 (% predicted)	89.0 ± 14.6	93.5 ± 13.7	0.049
FVC (% predicted)	97.0 ± 14.2	100.7 ± 14.0	0.108
FEV_1/FVC (% predicted)	78.3 ± 6.9	79.6 ± 7.9	0.339
VC (% predicted)	98.6 ± 14.0	103.6 ± 14.0	0.027
IC (% predicted)	115.0 ± 18.7	124.2 ± 16.2	0.037
ERV (liter)	0.59 ± 0.30	0.56 ± 0.31	0.621

undergoing bariatric surgery, the rate of respiratory post-operative complications was 7.5%, including O2 desaturation, symptomatic atelectasis, productive cough, dyspnea, pneumonia, and pulmonary thromboembolism. They found that the rate of pulmonary complications was higher in subjects with a restrictive lung function, rather than airflow limitation. In addition, they showed that not lung function, but OSAS is the only independent predictor of pulmonary complications in patients undergoing bariatric surgery [7]. In our study, inspiratory capacity and not airflow limitation seems to be a better marker for post-operative complications. Furthermore, we have shown that ESS, a symptom score for sleepiness, is the only significant predictor of pulmonary complications in the obese. Although, the percentage of subjects with previously diagnosed OSAS was low in the present study, sleepiness and OSAS could play a role in developing peri-operative complications as shown by Clavellina-Gaytán et al. [7] and should therefore be treated before surgery.

Limitations of this study are different time intervals between the retrospective and prospective cohort, 20% loss to follow-up in the prospective cohort, and the fact that the study was not primarily powered to predict complications. In addition, we only performed spirometry and did not measure lung volumes in the body box. Obesity often results in a decreased expiratory residual volume (ERV) and a decreased functional residual capacity (FRC) as a result of increased mass around the chest wall and in the abdomen. In the present study, the median ERV measured with spirometry was indeed decreased compared with a non-obese population. It is possible that lung volumes (FVC, IC) are better predictors of peri-operative complications as the result of the present study suggest. Another limitation is that in the obese patient, not only pulmonary physiology but also multiple mechanisms like cardiovascular and hormonal factors are involved in the risk of post-operative complications.

In conclusion, the 1-1-2 algorithm is useful to rule out patients with low risk of obstructive lung function. However, not airflow obstruction, but inspiratory capacity and ESS seem better predictors of (pulmonary) complications in morbidly obese subjects undergoing bariatric surgery.

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Compliance with Ethical Standards

Conflict of Interest Y. Türk, H.K Singh, A. van Huisstede, E. Birnie, U. Biter, and P.S. Hiemstra declare that they have no conflicts of interest. G.J. Braunstahl reports grants from GSK, grants from Novartis, grants from Chiesi, and grants from AstraZeneca, during the conduct of the study; personal fees from ALK-Abello, personal fees from Sanofi, personal fees from AstraZeneca, personal fees from Chiesi, and personal fees from Novartis, outside the submitted work.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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