Respiratory Function in Superobese Patients before and after Bariatric Surgery- a Randomised Controlled Trial

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Abstract: *Background:* Respiratory function decreases and risk of sleep apnoea increases with the degree of obesity. The impairment caused by obesity is a risk factor for complications in the perioperative period.

Objective: The aim of this randomised and controlled trial was to investigate respiratory function after bariatric surgery in superobese patients following laparoscopic gastric bypass (LGPB) or duodenal switch (LDS).

Methods: Superobese patients were randomised to undergo LGPB (n=16) or LDS (n=14). The procedures for anaesthesia, surgery and postoperative care were standardised. Spirometry and oximetry were assessed before surgery, after one and two days and one and two years postoperatively. The patients also answered a questionnaire about sleeping and snoring.

Results: Respiratory function transiently deteriorated significantly during the immediate postoperative period and significantly more after LDS. There were no significant differences between the groups after one and two years. Twenty-nine of the patients snored preoperatively and 22 two years after surgery. Eight reported sleep apnoea preoperatively and one after two years.

Conclusion: In the immediate postoperative phase, respiratory function is more impaired after LDS than LGPB. One and two years postoperatively all the patients' spirometry results were within normal range and they reported less problems with snoring and sleep apnoea.

Keywords: Bariatric surgery, obesity surgery, postoperative, respiration, sleep apnoea, snoring, spirometry.

INTRODUCTION

It is well known that obesity causes deteriorated lung function and increased risk of snoring and obstructive sleep apnoea syndrome (OSAS) [1-3]. In a recent publication Saliman *et al*. have presented data on pulmonary function in patients with Body Mass Index (BMI) 35-93 kg/m^2 [2]. The results indicate that the patients included generally had lung volumes within low-normal rates according to reference values. However, two volumes were remarkably low; the expiratory reserve volume (ERV) and the functional residual capacity (FRC) and this was explained by the restrictive pattern caused by the obesity [2]. The risk of developing OSAS rises also with increased body weight. In a general population the prevalence is about 4% [4], while the risk in obese patients has been reported as high as 77-88% [5, 6].

Patients undergoing abdominal or thoracic surgery are at risk of developing postoperative pulmonary complications. There are several pre-, peri- and postoperative risk factors for developing these complications as obesity, chronic obstructive pulmonary diseases, old age, immobilisation, duration of anaesthesia, location of surgery and pain [7-10]. Clinical guidelines, based on a systematic review of the literature on preoperative pulmonary risk stratification before non-cardiothoracic surgery have, however, concluded that there is no clinically meaningful increased risk for pulmonary complications for patients with morbid obesity [11]. These contradicting results may be due to the inclusion and exclusion criteria in the articles.

Conservative treatment of severe obesity often results in long term failure yet there can be initial achievements [12]. Despite many traditional non-surgical weight loss attempts the patients usually regain any weight they have lost [13]. Obesity is difficult to treat and the methods of treatment are many. The only method with a long-lasting weight reduction effect is surgery [14]. There are many different types of surgery but the Roux-en-Y gastric bypass is considered by many the "gold standard" [15, 16].

Weight loss after bariatric surgery by vertical banded gastroplasty or gastric bypass has been shown to give relief from cardiorespiratory symptoms. Patients have reported less apnoeas during sleep, improved dyspnoea and increased physical activity [17]. Thomas *et al.* have measured lung volumes in patients before and after undefined bariatric surgery. They found a small, but significant rise in forced vital capacity and forced expiratory volume in one second, but no change in peak expiratory flow. However, greater

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Table 1. Demographic Data of the Patients Undergoing Gastric Bypass or Duodenal Switch, Mean (SD) or n

	LGPB n=16	LDS n=14	p-value Between the Groups
Sex, F/M	11/5	9/5	NS
Age, years	34.1 (7.9)	36.3 (5.4)	NS
Height, m	1.70 (0.09)	1.70 (0.11)	NS
Weight preoperatively, kg	160.1 (21.2)	164.1 (22.8)	NS
BMI preoperatively, kg/m^2	55.1 (3.7)	56.34 (3.6)	NS
Weight one year postoperatively, kg	113.2 (21.6)	95.5 (13.0)	0.013
BMI, one year postoperatively, kg/m^2	38.8 (4.7)	32.9 (2.8)	p<0.001
Weight two year postoperatively, kg	110.1 (21.0)	88.6 (14.3)	0.003
BMI, two years postoperatively, kg/m^2	37.7 (4.5)	30.4 (2.9)	p<0.001
Smokers, n	6	7	NS
Diagnosed lung disease, n	4	2	NS
ASA-score 1/2/3	1/11/4	1/4/9	NS
Duration of anaesthesia, min	193 (41)	307 (68)	p<0.001
Duration of surgery, min	99 (37)	199 (56)	p<0.001

improvements in functional residual capacity, total lung capacity, residual volume and expiratory reserve volume were found after weight loss [18].

Morbidly obese patients undergoing gastric bypass surgery normally decrease about 33% of their weight, corresponding to 75% of excessive BMI [14]. For superobese patients (BMI >50kg/m^2) such a weight loss might not be sufficient to fully normalise cardiovascular risk and restore physical function. To be able to decrease even more in weight a duodenal switch may be an option. How pulmonary function and OSAS are affected by these two operations has not yet been evaluated in a randomised controlled setting.

The aim of this trial was therefore to investigate respiratory function, pulmonary complications and experience of sleep apnoea after bariatric surgery in superobese patients following laparoscopic gastric bypass or duodenal switch.

MATERIALS AND METHODS

This is sub study of a two-centre trial, conducted in two Scandinavian hospitals, Sahlgrenska University Hospital, Gothenburg, Sweden and Oslo University Hospital, Aker, Oslo, Norway. The main aim of the trial was to compare different effects of gastric bypass and biliopancreatic diversion with duodenal switch in morbidly obese patients. The patients gave their written consent to participate in the study after receiving verbal and written information. Sixty patients with a BMI 50-60 kg/m^2 at referral and aged 20-50 years were included from April 2006 and September 2007 and randomly assigned within the strata of sex, age (> or < 35 years), BMI (> or < 55 kg/m^2) and study centre. Inclusion and exclusion criteria are described elsewhere [19-21]. The data presented is from the patients who underwent surgery in Gothenburg, Sweden. Thirty patients were included and randomised to gastric bypass (n= 16) or duodenal switch (n=14). Demographic data of the patients are presented in Table **1**.

The patients included underwent standardised procedures that have been presented earlier [19, 20]. After surgery the patients received individualised pain relief. Pain less than 40 mm was endeavoured, measured using a visual analogue scale (VAS) of 100 mm.

All patients received preoperative information by a specialized physical therapist who emphasized the importance of early ambulation and to regularly change position when sitting/lying in bed postoperatively. The patients were instructed to perform 3 sessions of 10 deep breaths of positive expiratory pressure (PEP) using a mouthpiece (PEP/RMT set, Astra Tech AB, Mölndal, Sweden) every second hour during daytime. They were also instructed to huff and cough if needed. The resistance in the PEP device was tested individually but mid expiratory pressure was 10 cm H_2O during the exercises. The physical therapist and nurses supervised the training regularly so the technique could be corrected and resistance changed if necessary,

The patients were tested by spirometry and oxygen saturation measured the first 2 postoperative days and then again after one and two years. Tuffsat (Tuffsat, Datex-Ohmeda, US) was used to measure oxygen saturation and hypoxia was defined as a value of < 92%. Easyone (EasyOne, ndd Medical Technologics, Schweiz) was used to measure spirometry. The best result of three valid recordings of forced vital capacity (FVC) and peak expiratory flow (PEF) was used [22]. Predicted values in FVC and PEF were calculated for each patient according to Quanjer *et al.* [22]. The tests were performed in sitting as well as in the supine position in a standardised manner. The tests performed the first postoperative day were carried out when the patient had received sufficient pain relief and oxygen saturation was tested without any oxygen supply.

A, for this study developed questionnaire concerning snoring and sleep apnoea was administered before surgery, then one and two years postoperatively. The questionnaire has not been tested for validity or reliability. The 10 questions included were answered using one of the following statements: never, seldom, sometimes, often, very often or do not know. The questions were:

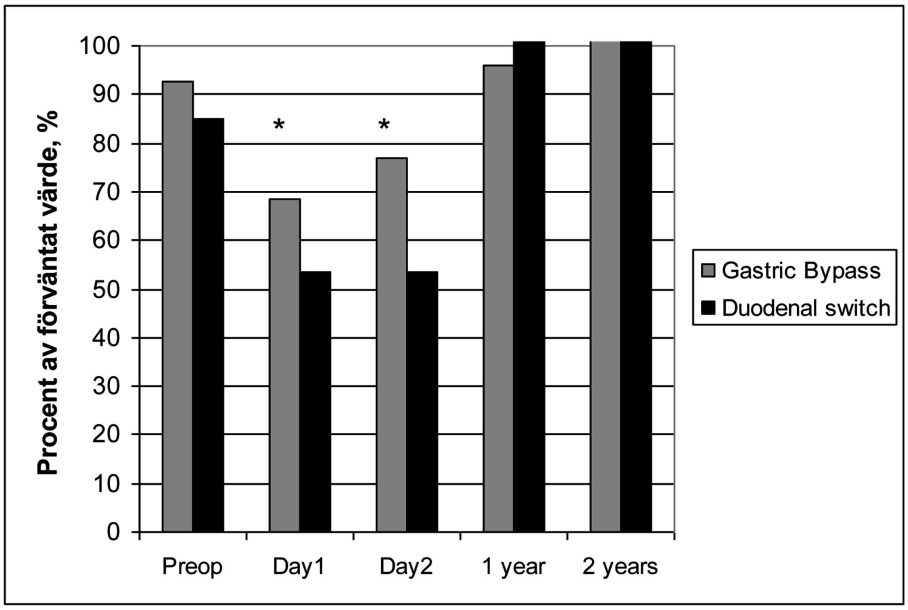

Fig. (1). Forced Expiratory Capacity (FVC) in percent predicted before and after laparoscopic gastric bypass vs. duodenal switch. * p<0.05 differences between the groups.

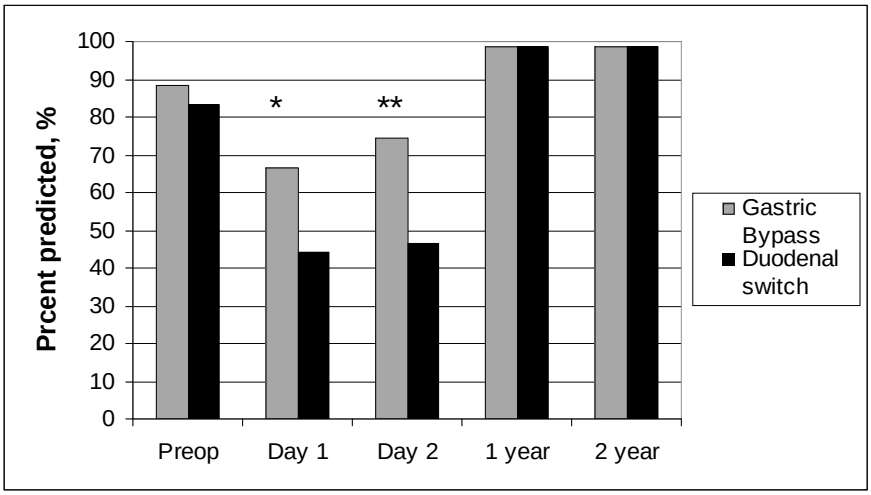

Fig. (2). Peak Expiratory Flow (PEF) in percent predicted before and after laparoscopic gastric bypass vs. duodenal switch. * p<0.05, ** p<0.01- differences between the groups.

1. Do you snore?
2. Do you suddenly wake up and feel that you cannot breathe?
3. Do you have sleep apnoeas during the night?
4. Do you wake up several times during the night?
5. Are you dry in your mouth when you wake up?
6. Do you wake up with headache?
7. Do you feel well-rested when you wake up in the morning?
8. Do you feel sleepy during the day?
9. Do you feel tired during the day?
10. Do you involuntarily fall asleep during the day?

ETHICS AND STATISTICS

The study has been performed according to the Declaration of Helsinki, and the Regional Ethics Committee in Gothenburg, Sweden has approved the procedure. Registration number S 688-02.

Because of the small sample size the answers in questionnaire concerning snoring were categorized to no/yes and differences between the groups were analysed by Fisher´s exact test. The continuous data was analysed by t-test. A p-value <0.05 was defined as significant.

RESULTS

Preoperatively

Results of the spirometry and oximetry are given in Table **2**. Saturation was found to be slightly lower than normal (97-99%) in both groups. Values FVC and PEF in percent predicted [22] are given in Figs. (**1** and **2**). FVC % predicted was on average 93% in the LGPB group and 85 % in the LDS group (n.s.) (Fig. **1**). Corresponding figures for PEF were 88% vs. 83% (n.s.) (Fig. **2**).

Table 2. Oxygen Saturation, Forced Vital Capacity (FVC) and Peak Expiratory flow (PEF) in Absolute Figures Mean (SD)

		LGPB n=16		LDS N=14	
		Lying supine	**Sitting**	**Lying supine**	**Sitting**
Saturation, %	Preoperatively	96.6 (0.9)	97.0 (1.0)	95.2 (1.8)*	95.9 (1.3)
	Postop day 1	94.4 (2.6)	94.8 (2.9)	92.8 (2.8)	93.9 (2.3)
	" day 2	95.7 (2.7)	96.6 (2.0)	92.8 (2.9)*	93.5 (2.9)**
	" 1 year	97.5 (1.6)	97.3 (2.2)	97.6 (2.0)	98.2 (1.7)
	" 2 years	97.5 (1.1)	97.5 (1.4)	97.0 (1.2)	97.6 (1.0)
FVC, liters	Preoperatively	3.5 (0.9)	3.7 (0.9)	3.3 (0.4)	3.4 (0.7)
	Day 1	2.4 (1.0)	2.8 (1.0)	1.8 (0.5)	2.1 (0.5)
	Day 2	2.8 (1.0)	3,1 (1.0)	1.8 (0.6)**	2.2 (0.6)**
	1 year	3.9 (1.0)	4.1 (0.9)	3.8 (0.7)	4.0 (0.8)
	2 years	3.9 (1.0)	4.2 (0.9)	3.9 (0.9)	4.1 (0.8)
PEF. liters/min	Preoperatively	409 (113)	418 (111)	355 (88)	388 (113)
	Day 1	264 (117)	318 (138)	197 (58)	205 (84)**
	Day 2	337 (138)	352 (124)	179 (53)***	224 (76)**
	1 year	438 (136)	462 (117)	436 (97)*	461 (112)
	2 years	439 (122)	476 (125)	432 (106)	464 (134)

*P<0.05, **p<0.01, ***p<0.001 (differences between groups)

Table 3. Results of the Questionnaire Concerning Sleeping and Snoring in Patients Undergoing Gastric Bypass or Duodenal Switch. Median (Range). There were No Significant Differences Between the Groups

		LGPB n=17	LDS n=13
Do you snore	Preoperatively	17	12
	1 year	12	5**
	2 years	14	8
Do you suddenly wake up and feel that you cannot breathe?	Preoperatively	4	8
	1 year	2	1**
	2 years	2	1**
Do you have sleep apnoeas during the night?	Preoperatively	4	5
	1 year	0*	1*
	2 years	0*	1
Do you wake up several times during the night?	Preoperatively	13	11
	1 year	8	3**
	2 years	7	8
Are you dry in your mouth when you wake up?	Preoperatively	16	12
	1 year	12	9
	2 years	12	11
Do you have headache when you wake up?	Preoperatively	12	11
	1 year	10	9
	2 years	10	9
Do you feel rested when you wake up in the morning?	Preoperatively	13	10
	1 year	12	11
	2 years	14	11
Do you feel sleepy during the day?	Preoperatively	15	13
	1 year	14	12
	2 years	13	11

Table 3. contd…

		LGPB n=17	LDS n=13
Do you feel tired during the day?	Preoperatively	16	13
	1 year	14	12
	2 years	13	12
Do you involuntarily fall asleep during the day?	Preoperatively	8	7
	1 year	3	1*
	2 years	4	1*

* p<0.05, ** p<0.01 within group differences compared to preoperative values

Results from the questionnaire concerning snoring are given in Table **3**. Twenty-eight patients snored regularly (28/29) and 9 reported that they were aware that they had apneas during sleep.

One Year Postoperatively

One year after surgery the LGPB patients had lost 16.3 BMI units and LDS patients 23.2 (p<0.001) (Table **1**). The weight reduction resulted in improved ventilation (Table **2** and Figs. **1** and **2**). There were no significant differences between the groups except for a significant increased PEF in supine lying in the DS group compared to the LGPB patients. All patients had a FVC within normal values (100 ±20%).

Results from the questionnaire about snoring indicated that the patients experience considerable improvement after surgery but there were no significant differences between the groups (Table **3**). Seventeen patients still snored and one patient experienced sleep apnoea.

Two Years Postoperatively

Two years after surgery the LGPB patients had lost 17.4 BMI units and LDS patients 25.8 (P<0.001) (Table **1**). The additional weight reduction resulted in minor increased ventilation (Table **2** and Figs. **1** and **2**). There were no significant differences between the groups. All patients had FVC values within normal range. Three patients in each group had a PEF below normal values defined as -20% of predicted values.

Results from the questionnaire indicated only minor differences compared to results after 1 year (Table **3**). There were no significant differences between the groups. Twenty-two patients snored and one patient still experienced apnoeas.

DISCUSSION

The biliopancreatic diversion with duodenal switch has been suggested as preferred treatment for patients with a BMI >50 as the weight loss could be greater thus increasing the likelihood of reaching a BMI <35 kg/m^2 after achieving peak weight loss [23-26]. However, there are different aspects to consider when comparing the two surgical techniques. We have previously reported perioperative and 1 year safety data, and 2 years follow-up findings in terms of BMI, anthropometric measures, concentrations of blood lipids, glucose, insulin, C-reactive protein, vitamins and health-related quality of life in this trial, which has demonstrated better weight loss after BPD/DS but similar improvements in other endpoints [19-21]. This article focuses on respiratory function and the results indicate that there are only minor differences between the groups. This might be due to the fact that the weight lost after both operations is sufficient to induce normalisation of respiratory function.

In this trial all patients were treated with breathing exercises with PEP and early ambulation. None of the patients developed pneumonia but 13% of those who underwent GBP and 21% of those who underwent duodenal switch had hypoxemia (>92% breathing air) postoperatively. The risk of postoperative pulmonary complications after VBG and gastric bypass has previously been described to be low [27,18], and even if the risk increases in superobese patients, as shown in our trial, the risk is relatively low. These findings are in accordance with results by Jensen *et al.* who followed 811 patients who had undergone laparoscopic bariatric surgery, 284 of which were diagnosed with OSAS and 144 were dependant on CPAP or BilevelPAP [28]. The patients received patient controlled analgesia, performed regular deep breathing exercises with Incentive Spirometry and were ambulated early and frequently postoperatively. They concluded that CPAP/BilevelPAP could safely be omitted even with patients with OSAS, provided that they are well observed, and that their pulmonary status is optimised by breathing exercises and mobilisation. With these contradicting results it is difficult to draw any specific conclusions about whether treatment with breathing exercises is needed and if so which treatment is most suitable. It does however appear that the use of deep breathing, such as with IS or PEP, is sufficient if combined with early and frequent mobilisation.

FVC is previously shown by Saliman *et al.* to be on average 83% of predicted values in women and 71% in men with an average BMI of 56-58 kg/m^2 [2]. The patients in our trial had an average FVC of 89 %. Anaesthesia and surgery normally causes deteriorations in lung volumes after laparoscopic obesity surgery [27,29]. Vital capacity after vertical banded gastroplasty was in those trials reported to be on average 60%, and 55% after gastric bypass during the immediate postoperative period. These new figures are based on patients with BMI 50-60 kg/m^2. As lung volumes deteriorate with increased weight it was anticipated that the patients in our trial would have had even lower FVC. This was however not the case, our patients deteriorated to 76% after gastric bypass and 64% after duodenal switch. Possible explanations for this may include developments in the laparoscopic technique and improved surgical skills combined with shorter and different types of anaesthesia.

The weight loss after a bariatric procedure increases the patient's lung volumes but in different degrees according to the extent of weight loss**.** When testing FVC an increase of 7% was seen in the trial by Thomas *et al.* [18]. The patients in our trial increased their FVC by 14% after GBP and 24% after duodenal switch. All patients were within normal limits 2 years postoperatively, which is important in a lifelong perspective.

PEF was used to evaluate the ability to perform a forced expiration i.e. to huff and cough. This was found to be on average 86% of predicted preoperatively and 58 vs 63 % for both groups the first postoperative days. The participants' ability to evacuate secretion was therefore greatly diminished. However, none of the patients developed postoperative pneumonia. The regular breathing exercises performed may have had an impact on the absence of such a complication. When measuring PEF 1 and 2 years postoperatively, the flow had on average increased to 95 vs. 99 % predicted.

In the analysis of the results between the groups only a few significant differences were found, however these differences were large. One likely explanation is the low number of patients for these variables. The primary variable that the study's power analysis was based on was reduction in BMI. The rather low study sample in this part of the trial does not give the opportunity to show significant differences in variables such as FVC. The results of this part of the trial may therefore be regarded as a pilot study and it is therefore of great importance to further evaluate the variables before final conclusions are drawn.

The results of quality of sleep and experiences of snoring and sleep apnoea indicate that the patients experienced major improvements. These findings confirm results from the Swedish Obese Subject Study [17]. However, our trial did not include any objective measurements, which may be regarded as a limitation. A polysomnography would have been a possible option [6]. Another limitation is that we used a, for this trial constructed questionnaire not tested for reliability and validity instead of an internationally often used one as the Epworth Sleepiness Scale [30]. Some of the questions can also be difficult to answer by the patients as if they snore or have sleep apnoea. Our results have therefore to be interpreted with caution and only as indications of the experiences the patients had.

CONCLUSION

In the immediate postoperative phase respiratory function is more impaired after LDS than LGPB. One and 2 years postoperatively all patients recorded spirometry values within normal limits and had less problems with snoring and sleep apnoea.

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Declared none.

CONFLICTS OF INTEREST

All contributing authors declare that they have no conflicts of interest.

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AUTHOR CONTRIBUTION

MFO and MW collected the data. All authors were involved in the planning of the study, analysing the data, interpretation of the analysing and writing the manuscript. Finally all authors have approved the submitted version.

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