The impact of bariatric surgery on the resolution of obstructive sleep apnoea

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Abstract

Objective: Obesity is associated with a high incidence of obstructive sleep apnoea (OSA). Bariatric surgery is postulated to lead to OSA resolution, but there is inconclusive evidence on its efficacy. We used objective measurements to determine the rate of resolution or improvement of OSA in patients who had bariatric procedures in our unit.

Results: Data was analysed on all patients with OSA who underwent bariatric procedures [laparoscopic Roux-en-Y gastric bypass (LRYGB) and sleeve gastrectomy (LSG)] between June 2012 and September 2016 in our unit. 47 patients (26.7%) were diagnosed with OSA. Mean age was 48.5 years. 63.8% were female. 43 required nocturnal continuous positive airway pressure (CPAP) support. Procedures were LRYGB (n = 26) and LSG (n = 21). Mean excess weight loss was 56.1%. Mean start apnoea-hypopnoea index (AHI) on CPAP was 6.4 events/hr and end AHI was 1.4 events/h. 14 patients (32.6%) had complete OSA resolution and 12 (27.9%) showed improvement in pressure support requirements. We demonstrated that 55.3% of patients had resolution or improvement in OSA following bariatric surgery. However, there was a high rate of non-attendance of follow-up appointments. Future efforts will involve analysis of the reasons for this to ensure more robust monitoring.

Keywords: Obesity, Sleep apnoea, obstructive, Bariatric surgery, Continuous positive airway pressure, Weight loss

Introduction

Obstructive sleep apnoea (OSA) is strongly correlated with obesity. The incidence and severity of OSA rise with increase in body mass index (BMI) [1, 2]. Estimates of the prevalence of OSA in obese patients (BMI > 35 kg/m²) vary due to variations in diagnostic methodology and screening tools [3, 4]. It is characterised by recurrent upper airway obstruction during sleep leading to hypoxaemia and frequent awakening. Excessive daytime sleepiness is a cardinal symptom [5]. OSA is associated with adverse cardiovascular events and increased mortality from various causes including metabolic disease and cancer [6].

Current treatment includes behavioural changes, with the gold standard being the use of non-invasive continuous positive airway pressure (CPAP) devices [4, 7]. However while this is associated with improvements in health-related quality of life [4], it is not curative and there are often issues with concordance with therapy [8]. Recent trials have suggested minimal impact on objective outcomes such as adverse cardiovascular events [7, 9].

Bariatric surgery has been postulated to cause OSA resolution. A randomised controlled trial of laparoscopic adjustable gastric banding (LAGB) versus conventional weight loss methods in 60 obese patients with OSA found that while there was significantly greater excess weight loss (EWL) in the surgery group, both groups had significant decreases in the apnoea-hypopnoea index (AHI) [10]. Conversely, another randomised trial of CPAP versus LAGB in 49 patients showed a significant decrease in AHI in patients on CPAP compared with those who had LAGB, despite significantly greater weight loss in the LAGB group [11].

A systematic review by Sarkhosh et al. analysed pooled data from studies across 13,900 patients, and showed improvement or resolution in OSA after bariatric surgery in 88.5% of patients [12]. The effect was most marked...
with procedures with a malabsorptive mechanism (bili-
pancreatic diversion and gastric bypass). Another
systematic review comparing bariatric surgery with non-
surgical weight loss showed significant reduction in post-
operative AHI in surgical compared with non-surgical
patients [13]. However, most both studies combined data
across heterogeneous studies to give pooled averages,
with a high risk of bias.

The efficacy of bariatric surgery in the resolution of
type two diabetes mellitus is conclusive [14], however
data on its efficacy in OSA is less robust, due to differing
study designs, low numbers of well-powered randomised
trials, as well as insufficient concordance about screening
methods and objective measurements of outcomes [15].
We aimed to determine the degree of improvement or
resolution of OSA in our patient group using objective
measures.

Main text

Methods

Patient selection
In the United Kingdom, adults with a BMI ≥ 40 kg/m² or
BMI ≥ 35 kg/m² with defined comorbidities are eligible
for referral to a Bariatric surgery service from primary
care via a Tier 3 dietetic service, as per guidelines from
the National Institute of Health and Care Excellence [16].
The Bariatric service in Worcestershire was established
in June 2012. All patients are screened for OSA pre-
operatively using a combination of reported symptoms
(particularly excessive daytime sleepiness and snoring),
and Epworth Sleepiness scale (ESS) questionnaire (Fig. 1)
[17]. An ESS of ≥ 10 triggers referral to the Clinical Inves-
tigations Unit for a home sleep study consisting of pulse
oximetry, nasal flow, thoracic and abdominal movements
and the measurement of movement and body position.
The sleep studies are analysed by appropriately trained
respiratory physiologists and an AHI score calculated. An
AHI of >10 triggers referral to the sleep clinic for further
evaluation and commencement of nocturnal CPAP ther-
apy if appropriate.

Data collection
A retrospective review of the prospectively maintained
database of all patients between June 2012 and Septem-
ber 2016 who had bariatric surgery and were diagnosed
with obstructive sleep apnoea was performed. Demo-
graphic details, start weight and BMI, end weight and
BMI, % excess weight loss (EWL), pre- and post-operat-
ive AHI, requirement for CPAP therapy with start and
end (if applicable) pressure settings were reviewed. Dura-
tion of follow-up and any losses to follow-up were also
recorded.

Statistical analysis
All values are expressed as mean ± standard deviation
(SD) unless otherwise stated. %EWL was calculated as
(start weight − end weight)/(start weight − ideal
weight) × 100, with ideal weight given as that equiva-
 lent to a BMI of 25 kg/m². Data was tested for parame-
tricity using the Kolmogorov–Smirnov test. Differences
between two groups with numerical data were tested
using the two-sided student t test. Differences between
groups with categorical data were tested using the χ² test.
Correlation between groups was tested using the Spear-
man rank correlation test. The statistical program used
was GraphPad Prism version 5.

Results
Of 176 patients in the database, 47 were formally diag-
nosed with OSA (26.7%). 63.8% of patients were female
with a mean age of 48.5 years. The two procedures per-
formed were laparoscopic Roux-en-Y gastric bypass
(LRYGB) (n = 25) and laparoscopic sleeve gastrectomy
(LSG) (n = 22). There were no significant differences in
age, sex or start weight and BMI between the LRYGB and
LSG groups. Patients with Type 2 diabetes mellitus were
more likely to have the Roux-en-Y gastric bypass proce-
dure (Table 1).

43 patients required nocturnal CPAP therapy. 4
patients were deemed not to require CPAP therapy after
review in the sleep clinic. Of the 43 who were started on
CPAP, the pre-operative AHI (whilst on CPAP therapy)
and CPAP settings were available for 38 patients. There
was a trend towards a higher start AHI in the LSG group
(mean start AHI in the LRYGB group was 4.7 ± 4.7
events/h compared with 8.7 ± 7.1 events/h in the LSG
group, p = 0.049). However, CPAP settings were similar
for both groups (11.8 ± 3.0 cmH2O in the LRYGB group
versus 10.7 ± 2.3 cmH2O in the LSG group, p = 0.19).

Mean duration of follow-up was 15.6 ± 10.6 months.
12 patients were lost to sleep clinic follow-up (25.5%); of
these 10 did not attend scheduled appointments and 2
were non-adherent with the CPAP device and sleep clinic
instructions.

At the end of the study period, mean excess weight
loss was 56.2 ± 14.2% (average 39.6 kg weight loss) with
a mean BMI of 36.4 ± 5.7 kg/m². There was a significant
decrease in the mean AHI post-operatively (p < 0.0001).
14 patients no longer required CPAP and were dis-
charged from the sleep clinic (29.8%). A further 12
showed partial resolution with marked decreases in AHI
and CPAP pressure settings, while 9 (19.1%) showed no
objective improvement in settings (Table 2). At the end of
the study period, 21 patients were still on CPAP therapy
(44.7%) compared with 91.5% at the beginning.
Epworth Sleepiness Scale

Name: ___________________________ Today’s date: ________________

Your age (Yrs): ________________ Your sex (Male = M, Female = F): _______

How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired?

This refers to your usual way of life in recent times.

Even if you haven’t done some of these things recently try to work out how they would have affected you.

Use the following scale to choose the most appropriate number for each situation:

0 = would never doze
1 = slight chance of dozing
2 = moderate chance of dozing
3 = high chance of dozing

It is important that you answer each question as best you can.

| Situation                                           | Chance of Dozing (0-3) |
|-----------------------------------------------------|------------------------|
| Sitting and reading                                 | ______________________ |
| Watching TV                                         | ______________________ |
| Sitting, inactive in a public place (e.g. a theatre or a meeting) | ____ |
| As a passenger in a car for an hour without a break | ______________________ |
| Lying down to rest in the afternoon when circumstances permit | ____ |
| Sitting and talking to someone                      | ______________________ |
| Sitting quietly after a lunch without alcohol       | ______________________ |
| In a car, while stopped for a few minutes in the traffic | ______________________ |

THANK YOU FOR YOUR COOPERATION

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Fig. 1 Epworth sleepiness scale [17]
Mean EWL was greater in the LRYGB group compared with the LSG group ($p = 0.036$) and end AHI also appeared lower in this group ($p = 0.039$). There were no other significant differences between the two groups.

Correlation analyses were performed between EWL and end AHI and CPAP requirements, where available. There was no significant association found between EWL and end AHI or CPAP settings ($r^2 = −0.28$ ($p = 0.17$), between EWL and end CPAP $r^2 = −0.24$ ($p = 0.20$)).

**Discussion**

In our study, 26.7% of patients who underwent weight loss surgery were diagnosed with OSA pre-operatively. Estimates of the prevalence of OSA in both obese and non-obese populations vary widely, thought mainly to arise due to differences in diagnostic criteria and screening tools used [4]. The incidence in the Wisconsin Sleep Study was estimated at 24 percent in men and 9% in women [1]. The current gold standard diagnostic tool is polysomnography in a sleep laboratory with an attendant technologist. However, this is expensive and cumbersome. Many screening tools have been developed to risk-stratify patients to determine suitability for further diagnostic testing, each with its limitations. The most well-established include the Epworth scale (the commonest tool in routine clinical practice) [17, 18], the STOP-Bang [19], Berlin [20] and Wisconsin sleep questionnaires [1]. They have all been validated in referral settings so their accuracy in a routine screening population is still untested [4].

Our study shows significant improvements in OSA after bariatric surgery, with 55.3% of patients demonstrating significant improvement or resolution using objective criteria. While this is a lower rate of resolution than in some of the published literature [12, 21, 22], it is based on objective measurements obtained from serial measurements during sleep clinic review rather than patient-reported symptoms as in much of the reported literature [12]. Although average pre-operative AHI readings whilst on CPAP were already below 10 events per hour (due to effective CPAP therapy), there were statistically significant decreases in AHI post-operatively. Based on these results, 30% of patients were successfully weaned off CPAP. Due to losses to follow-up, it is expected that the true proportion with complete resolution is higher.

The mechanisms through which this resolution occurs are still being elucidated. The “BRAVE” hypothesis (bile flow alteration, reduction of gastric size, anatomical gut rearrangement and altered flow of nutrients, vagal manipulation and enteric gut hormone modulation) proposed by Ashrafian et al. [23] postulates that both weight-dependent and weight-independent metabolic effects play a role. We observed that improvements in AHI measurements and CPAP weaning occurred over several months. This is strikingly different from the rapid resolution of Type II diabetes typically observed after bariatric surgery (particularly RYGB). There did not appear to be a correlation between EWL and AHI or CPAP settings in this study, but statistical analysis was hampered by the small sample sizes due to losses to follow-up. In the future, anatomical measurements (such as neck size) and measurement of various hormone profiles will give a clearer understanding of the mechanisms and trajectory of resolution over time, as well as its link with excess weight loss.

**Limitations**

Our primary screening tool was the Epworth scale, with a threshold for referral for a sleep study set at 10 or more on this scale. We acknowledge the potential risk that

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**Table 1 Patient demographics**

|                      | LRYGB group (n = 25) | LGS group (n = 22) | p value | All patients (n = 47) |
|----------------------|----------------------|--------------------|---------|----------------------|
| Age (years)          | 50.7 ± 10.2          | 46.0 ± 7.8         | 0.08a   | 48.5 ± 9.3           |
| Sex (% female)       | 64.0                 | 63.6               | 0.98b   | 63.8                 |
| Start weight (kg)    | 145.2 ± 22.6         | 139.5 ± 21.6       | 0.38a   | 142.5 ± 22.1         |
| Start BMI (kg/m²)    | 52.1 ± 7.4           | 49.8 ± 7.8         | 0.31a   | 51.0 ± 7.6           |
| % T2 diabetes        | 560                  | 22.7               | 0.01b   | 42.6                 |

* a $t$ test  
* b $\chi^2$ test

**Table 2 Objective measurements pre- and post-operatively**

|                     | Start (pre-operative) | End (post-operative) | p value |
|---------------------|-----------------------|----------------------|---------|
| Weight (kg)         | 142.5 ± 22.1          | 102.9 ± 19.1         | < 0.001 |
| BMI (kg/m²)         | 51.0 ± 7.6            | 36.4 ± 5.7           | < 0.001 |
| AHI (events/hr)     | 6.4 ± 6.1             | 1.4 ± 1.7            | < 0.001 |
| CPAP settings       | 11.1 ± 2.7            | 10.1 ± 2.7           | 0.17    |
some patients with OSA, but no symptoms of excessive sleepiness, were not tested. The cost-effectiveness of routine sleep studies on all patients who present for Bariatric surgery is the subject of debate [4, 18].

There was a relatively high rate of non-attendance of follow-up sleep clinic sessions. Non-adherence to CPAP therapy is common in patients with OSA [24], with an estimated 46–83% of patients non-adherent with their CPAP device [25]. Many people with OSA are asymptomatic [26] therefore may not subjectively feel any benefit following treatment. Our patients report subjective improvements in sleep-apnoea related-symptoms after Bariatric surgery, tied to improvements in other co-morbidities. Some of these patients who subsequently attended Bariatric clinic follow-up had voluntarily ceased CPAP therapy. However, this needs to be correlated with objective measures. We are working to integrate the sleep clinic follow-up with the Bariatric service to ensure better adherence to follow-up and robustness of future data collection.

In summary, this study shows a clear benefit of Bariatric surgery to a group of patients with an established obesity-associated metabolic disorder with associated morbidity and mortality and costs from ongoing therapy. This adds to the body of literature supporting the role of Bariatric surgery in treating sleep apnoea and we believe that it should be routinely recommended for curative benefit in this patient group.

Abbreviations
AHI: apnoea-hypopnoea index; BMI: body mass index; BRAVE: bile flow alteration; reduction of gastric size; anatomical gut rearrangement and altered flow of nutrients; vagal manipulation and; enteric gut hormone modulation; CPAP: continuous positive airway pressure; ESS: epworth sleepiness scale; EWL: excess weight loss; LAGB: laparoscopic adjustable gastric banding; LRYGB: laparoscopic Roux-en-Y gastric bypass; LSG: laparoscopic sleeve gastrectomy; OSA: obstructive sleep apnoea.

Authors’ contributions
MSW and TOS were involved in the conception and design of the study. TS and MA collected and analysed data. SL-O analysed the data and critically revised the manuscript. KA-M and EW maintained the prospective database and contributed to data analysis. PL-P contributed to the data analysis and manuscript revision. AP and SJR contributed to critical review of the manuscript. All authors read and approved the final manuscript.

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Competing interests
The authors declare that they have no competing interests.

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