Original Article

Obstructive Sleep Apnoea (OSA) Patterns in Bariatric Surgical Practice and Response of OSA to Weight Loss after Laparoscopic Adjustable Gastric Banding (LAGB)

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Abstract

Introduction: This study aims to evaluate the incidence of Obstructive Sleep Apnoea (OSA) in severely obese Asians and to study the impact of weight loss on OSA. Materials and Methods: We report the results of routine preoperative Polysomnograms in 350 Asian patients undergoing bariatric surgery in our institute. Polysomnograms were repeated in 75 randomly selected patients with moderate to severe OSA after target weight loss with the laparoscopically placed adjustable gastric band (LAGB). Results: The prevalence of OSA in obese Asians is high. Moderate OSA was found in 46% of patients and severe OSA was found in 33%. Severe OSA was significantly more in the Chinese (46%) compared to the Malays (29%) or Indians (21%) (*P* = 0.035). We identified other risk factors for severe OSA (male sex, higher body mass index and the presence of hypertension) but were unable to select identifying parameters for very low (<5%) likelihood of severe OSA such that routine sleep studies prior to bariatric surgery could be omitted. Apnoea Hypoapnoea Index (AHI) showed improvement of 50% at 20 kg excess weight loss with the cure of OSA in preoperatively severe cases (*P* <0.005). Mild to moderate cases reported similar improvements although a direct correlation could not be established. Desaturation events, apnoea episodes, work of breathing and subjective assessment of sleepiness scores and quality of life (QOL) showed improving trends, albeit not statistically significant. Similar improvements were seen in sleep architecture with increased rapid eye movement (REM) and stage 3 sleep. Conclusions: The incidence of OSA in Asians undergoing bariatric surgery is high. Routine sleep studies in Asian patients are justified. Weight loss brought about a significant improvement in AHI and continuous positive airway pressure requirements. LAGB placement should be considered a broadly effective therapy for sleep apnoea in the severely obese patient.

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Introduction

The incidence of OSA in severely obese Asians is poorly documented. This is also compounded by a varied racial profile across Asia. Singapore, with its mixed ethnic population is uniquely poised to study the prevalence of sleep disturbances and the results of different interventions. In this study we sought to evaluate the prevalence of obstructive sleep apnoea (OSA) in bariatric surgical practice in Singapore and attempt to formulate guidelines for preoperative polysomnograms. We sought to evaluate any identifying parameters to predict a higher chance of having OSA or those with a very low likelihood of OSA such that routine preoperative polysomnograms could be avoided. Polysomnograms were repeated to evaluate the effects of surgically induced target weight loss on different aspects of sleep disordered breathing which has not been well described so far in the Asian setting.

Obesity is a proven risk factor for OSA and the prevalence rates amongst the obese vary from 8% to 48% thus imparting a 10-fold increased risk.[1-3] Approximately 70% of individuals

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with OSA are obese.[4] Obese individuals, perhaps because of morphologic characteristics are at heightened risk of airway collapse. One of the main factors linking obesity to OSA is the anatomy of the area surrounding the collapsible region of the pharynx, which is critical to airway patency. Obese individuals have extrinsic narrowing of this area and regional soft tissue enlargement. Another consideration in obese individuals is the distribution of fat with predilection for fat accumulation in the viscera and trunk. OSA increases the burden of obesity by inducing alveolar hypoventilation and contributes other cardiopulmonary consequences of pulmonary hypoventilation such as pulmonary hypertension and cor pulmonale.

The defining event of OSA is the partial or complete cessation of airflow during sleep caused by occlusion of the upper airway.[5] Apnoea causes hypoxia and strenuous ventilatory efforts, which are followed by arousal to a lighter stage of sleep and restoration of airway patency and airflow. This sequence can occur hundreds of times during the night.[6,7] The apnoea hypopnea index (AHI), the number of apnoeic and hypopnoeic events per hours of sleep, quantifies the severity of OSA.[8-10]

Some previous studies have documented improvement in OSA after surgically induced weight loss, although most of these are from the Western world and usually have been in very small cohorts of patients.[11-13] Intentional weight loss does appear to have major sleep benefits for obese subjects and these improvements are known to be consistent across different methods of weight loss.[14-16]

Materials and Methods

The study was approved by the Institutional Review Board (DSRB Ref: D/06/219 dt July 2006). Bariatric surgery was introduced at our hospital in 2001 as part of a multidisciplinary weight management programme. We have been performing an average of 100 laparoscopic adjustable gastric bands (LAGB) each year. The study was performed in a single centre.

Patient Selection

Asian criteria were used in selecting patients for bariatric surgery.[17] Patients must have a body mass index (BMI) of 32.5 and above with an obesity related co-morbidity or BMI 37.5 and above with or without any co-morbidity. One patient in this study had a fall in BMI from 32.5 to 32 at the time of surgery after conventional weight loss measures, but was operated upon in view of inability to have ongoing weight loss in the face of newly acquired multiple co-morbidities which were likely to be immensely benefitted by continued progressive weight loss. We accepted the definition of hypertension as a blood pressure reading of 140/90 mm of Hg or greater (MOH Clinical Practice Guidelines, June 2/2005). Cases were designated as either existing, with ongoing medications and follow-up or newly diagnosed, based on blood pressure readings of 140/90 mm of Hg or greater on 3 separate clinic visits with previous records of normal readings for at least 2 years. We recorded an improvement when there was a fall in blood pressure readings and/or reduced medication requirements. The cure, as recorded in newly diagnosed cases was stated when postoperative blood pressure readings were 135/85 mm of Hg or lower without medications. All patients underwent a preoperative overnight sleep study which was scored using standard criteria. We based our diagnosis of OSA primarily on the AHI. An AHI of 15/hour and above is taken to indicate significant OSA and an AHI of 30/hour and above indicates severe OSA. The results of the first 350 patients were analysed to look at the incidence of OSA and predictors of OSA including racial differences. Ninety per cent of our patients completed overnight sleep studies. Sleep studies were repeated in 75 randomly selected patients who had significant OSA prior to surgery. These patients were selected randomly from our database by a nurse clinician who was not involved in the study. The overnight sleep study was repeated at least 1 year after surgery and after achieving a target weight loss of at least 20 kg. Informed consent for participation was obtained from every participant in the study. A total of 46 successful studies were analysed.

The Laparoscopically-placed Adjustable Gastric Band (LAGB)

LAGB surgery involves the placement of an adjustable silicone gastric band (Lap-Band System®, Inamed Health, Santa Barbara, CA, USA or the SAGB, J&J) just below the gastro-oesophageal junction. The band has an inflatable inner balloon that can be adjusted by adding or removing normal saline via a subcutaneous access port. An extensive systematic review recently showed the long-term sequelae of the LAGB.[18] We have an ongoing survey analysis of LAGB outcomes using the BAROS (Bariatric Analysis and Reporting Outcome System).

Polysomnography

Each patient had a full diagnostic PSG performed which included the following recordings

1) electroencephalography
2) leg electromyography
3) airflow via a thermistor
4) oxygen saturation and heart rate monitoring

A single qualified sleep physician supervised every study. A trained sleep technician reported each study using accepted criteria and scored each study for arousals using ASDA criteria. Our sleep study laboratory follows guidelines set by the AASM (American Academy of Sleep Medicine) Manual for Scoring Sleep, 2007 (www.aasmnet.org). Presenting the entire set of criteria is beyond the scope of this study, however, we present a few salient points.

1) Apnoeas were defined as complete cessation of airflow >/= 10s. Hypopnoeas were defined as greater than 50% reduction in 1 of 3 respiratory signals – airflow signal, or respiratory or abdominal signals of respiratory inductance plethysmography, with an associated fall of >/=2% in oxygen saturation. The sensor to detect absence of airflow for identification of an apnoea is an oronasal thermal sensor. The sensor for detection of airflow for identification of hypopnoea is a nasal air pressure transducer. Pulse oximetry is used for the detection of blood oxygen with a maximum acceptable averaging time of 3 seconds.

2) For sleep stages, the following terminology is used
   a) Stage W (wakefulness)
   b) Stage N1 (NREM1)
   c) Stage N2 (NREM2)
   d) Stage N3 (NREM3)
   e) Stage R (REM).

3) Sleep stages are scored in 30 second sequential epochs with a stage assigned to each epoch

Data Analysis

Retrospective evaluation of our sleep study database was performed using chi-square test, Mann-Whitney U test and Spearmans rho (2-tailed) test. Retrospective evaluation of paired variables to check for correlation was done using the Karl Pearsons coefficient (r = ± 1). Unpaired Student's *t*-tests were used to assess the differences between subjects. Individuals with paired questionnaire and sleep test results were assessed using the parametric paired Students *t*-test and non-parametric Wilcoxon sign test, as appropriate. χ^2 method (Fisher's exact test) was used to test the significance of differences between proportions and categorical variables. Variables were assessed for correlation using Spearmans non-parametric bivariate analysis. A *P* value of less than 0.05 was considered statistically significant.

Results

Ninety per cent of all patients coming for LAGB completed overnight sleep studies in our institute. One hundred and sixty-one patients (46%) had significant OSA (AHI 15/hour or greater) and 105 patients (33%) had severe OSA (AHI 30/hour or greater) (Tables 1, 2 and 3). All patients with moderate to severe OSA were given continuous positive airway pressure (CPAP) therapy.

Table 1. Overall Patient Demographics

Clinical parameters	Median	Range
Height	1.64 m	1.42-1.87 m
Weight	112 kg	71.5-204 kg
BMI (kg/m^2)	41.9	32-73
Age	36 years	18-63 years

Sex - M/F: 127 (36.3%)/223 (63.7%)

Table 2. Overall Patient Demographics

Race	Singapore population	No. of patients	% with severe OSA
Chinese	76.5%	150	46
Malays	13.6%	95	29
Indians	8.2%	84	21
Others	2.1%	21	---

Table 3. Overall Prevalence of OSA-Our Series

Not completed		36
• 0-5/hr	Normal	86
• 6-14.9/hr	Mild OSA	67
• 15-30/hr	Moderate OSA	56
• Above 30/hr	Severe OSA	105
		350

Analysis of patients with OSA did not show any correlation between BMI and AHI as shown in Table 4. A correlation study (Karl Pearsons) of the whole database including mild cases and those with no OSA (marked as AHI = 0) did not show any correlation between increasing BMI and severity of OSA (r = 0.0014). Analysis of clinical factors associated with OSA confirmed a positive association with male sex (*P* <0.001 Mann-Whitney U test), higher body weight, higher BMI, higher excess weight (*P* <0.0001 Spearman's rho/2-tailed) and the presence of hypertension (*P* = 0.001, Mann-Whitney U test). No individual factor or combination of factors could be identified which reliably predicted the absence of severe OSA (<5% chance). This reinforced our decision to support routine preoperative sleep studies. The Chinese had an overall higher risk of OSA than the risk in Malays or Indians even though the distribution of sex, weight, excess weight, BMI and hypertension is

Table 4. BMI And OSA Severity

BMI kg/m2	AHI range (mean)	Number
32-35	17.1 -38.9 (22.1)	25
35.1-37.5	16.1-71.7 (35.43)	30
37.6-40	15.5-106.5 (25.55)	26
40.1-42.5	15-93.1 (48.15)	24
42.6-45	17.1-73.9 (69.84)	17
45.1-50	15-133.8 (77.67)	22
50.1-75	15.1-86.1 (36.27)	17

Pearson's coefficient (r) = 0.0014. (entire pool)

similar across the 3 racial groups in our pool (P = 0.035 chi-squared test).

Polysomnography

All patients from the database who were randomly selected after being eligible agreed to have a repeat PSG.A total of 46 successful studies were available for analysis. The second PSG was performed at 12.6 +/- 20 (range, 12 to 40) months after surgery. At the time of the study, the subjects had lost a mean of 41.1 kg (range, 20 to 60.3) of weight and 66% to 120% of excess weight (Table 4). Average preoperative BMI was 45.2 kg/m^2 (range, 33 to 60). Average postoperative BMI was 30 kg/m^2 (range, 23 to 40.3). Repeat study showed a significant fall in AHI and arousal index at 20 kg excess weight loss. AHI showed improvement in all patients except one, the fall in mean values of AHI being 38.11 to 13.18 (P = 0.001) and a mean difference in AHI (of individual pairs) of 24.92 (standard deviation, 24.86) with a 95% CI of difference of between 16.50 and 33.33 (Sig/2-tailed = .000). Overall, OSA showed a cure in 78% of cases such that in these patients the AHI fell from any preoperative value to 5/hr or less after target weight loss. An average benefit of 50% fall in AHI values was noted at 20 kg weight loss. Our analysis showed that a 1 kg weight loss resulted in up to a maximum of 9.5% reduction of AHI and 1 unit change in BMI resulted in up to 9.9% reduction of AHI. Change in weight is a better predictor of fall in AHI as compared to BMI (1.062 vs 0.832). In our pool of repeat PSG study cases, 17 had AHI of greater than 25. Three of these patients still had an AHI greater than 25 after target weight loss despite a fall, thus continuing CPAP requirements. Hypertension and diabetes showed improvements of up to 83% to 86% requiring reduced or no medications which included a reversal of newly acquired hypertension in 10 patients. The other parameters showing significant improvement were the increase in REM and stage 3 sleep. Other noteworthy changes were an uniform improvement of apnoea measurements (central vs obstructive), lesser desaturation episodes, higher lowest and average saturation, shorter apnoea episodes and snoring statistics.

Discussion

The association between obesity and OSA is compelling. Total body weight, BMI and fat distribution all correlate with the odds of having OSA. Obesity and OSA are associated with numerous disease conditions like systemic hypertension, heart failure, pulmonary hypertension, coronary artery disease and stroke.[19] Sleep apnoea has a significant bearing on the pre and postoperative care of the bariatric surgical patient and therefore it is important that it is both diagnosed and treated preoperatively. Although simple pulse oximetry and the Epworth Sleepiness Scale are not entirely reliable, some scoring systems have been deemed to be useful to predict the prevalence of OSA.[20] It is estimated that an average of 100,000 bariatric surgical procedures will be performed every year in the United States (US) alone and Bariatric surgery is currently also exploding onto the scene in Asia. Increased awareness of the risk posed by an obstructed airway and appropriate management are important to optimise the perioperative care of patients with OSA. The incentive to diagnose sleep apnoea preoperatively is to reduce the perioperative complication rate of bariatric surgery. OSA can be induced, unmasked or exacerbated by effects of sedative, analgesic and anaesthetic agents regardless of site of surgery. Immediate postoperative complications may intuitively be attributed to the negative effects of sedative, analgesic and anaesthetic agents which can worsen OSA by decreasing pharyngeal tone and arousal responses to hypoxia, hypercarbia and obstruction. Later events are more likely related to postoperative REM sleep rebound which can conceivably act in conjunction with opoid administration and supine posture to aggravate sleep disordered breathing. REM sleep rebound has been suggested to contribute to confusion, delirium, myocardial ischaemia, stroke and wound breakdown.[21] Some studies have shown positive correlations with anastomotic leaks and other variables like complication rates and length of stay with untreated OSA.[22] There is no direct evidence to suggest that preoperative treatment of OSA would change the outcome of surgery for the better or worse. Some researchers, however, have implied an indirect affect on the outcome of surgery in cases with preoperative treatment of OSA.[23,24]

A literature review has shown that every 10 kg increment in body weight increases OSA risk 2-fold; every 6 kg/m^2 increment in BMI increases OSA risk more than 4-fold; and each increase in waist or hip circumference by 13 to 15 cm increases OSA risk approximately 4-fold.[25] Weight loss provides improvements in respiratory events during

Table 5. Table Showing Statistical Analysis of Post-LAGB Changes in Clinical Variables

	Pre-LAGB	Post-LAGB	Mean	SD	SE Mean	95% CI upper lower	Sig 2 tailed	*P*
BMI (kg/m²)	33 - 60 (45.2)	23 - 40.3	30					<0.001
Weight (kg)	71.5 - 204 (111)	51.5 - 141 (70.86)*	41.1†					<0.001
Hypertension	n = 31	n = 21						0.05
AHI‡	16.6-137.7	0.6-91.7	24.9	24.86	4.14	- 33.33 /- 16.50	.000	<0.001
Average O_2 saturation‡	94.21	96.75	2.5	4.03	0.72	1.06 /4.02	.01	
Lowest O_2 saturation‡	77	82	7.01	33.24	5.97	5.8 /-19.2	.001	
Desaturation episodes‡	95	0	123	170.38	31.10	-59.4 /-186.64	.000	
Snoring‡	184§	54§	1.49¯	3.97	0.72	- 0.016 / -2.78	.048	
Arousal Index	48.2 (± 34)	18.4 (± 13)						0.55
Sleep Efficiency	71 (± 18)	79 (± 10)						0.02
REM sleep	25(± 22)	0 (± 21)						<0.001
REM/total sleep (%)	8.1(± 6.1)	17.2(± 6.1)						<0.001
Stage 3 & 4/ NREM (%)	17(± 13)	27 (± 10)						<0.001

*: mean postoperative weight

†: mean weight lost

‡: paired samples test

§: Mean snoring episodes
values- (± standard deviation)

sleep, subjective sleepiness, biochemical measures of the metabolic syndrome and symptoms of depression and body image. These changes presumably also underlie the remarkable improvement in quality of life.

Sleep study data on Asian patients has been very scarce. Most previous such studies have been from the Western world with Western populations. In this study apart from documenting OSA prevalence in Asians, we have shown that significant weight loss has major benefits for severely obese subjects with OSA. Our data clearly showed that OSA is common in severely obese Asians and this has also been noted previously. The exceptionally high risk of OSA in severely obese Chinese is probably related to racial differences in cranial and upper airway morphology which have also been documented in the Japanese.[26-28]

This study, based upon a very high prevalence of OSA among obese Asians, supports the notion of routine polysomnograms prior to surgery with particular emphasis amongst ethnic Chinese and other variables such as male sex, hypertension and a higher BMI. Our study was not designed to study factors predicting absence of any sleep disordered breathing, but based on clinical data in our pool, we were unable to identify any clinical pamameter(s) so as to cluster patients into group(s) predicting very low likelihood of OSA such that routine polysomnograms could be completely avoided in these patients. We believe that a preoperative sleep study should be part of standard work for bariatric surgery and our policy is also echoed by some previously published results.[29] In this study we followed a policy of routine polysomnograms for the preoperative diagnosis of OSA which we believe is a gold standard, unlike other researchers who have been using scoring systems to predict likelihood. We showed that sleep apnoea is very prevalent across all BMI groups presenting for bariatric surgery. Unlike other studies, we did not find a correlation between BMI and severity of OSA in these obese patients as can be seen by the AHI values across different BMI groups. A correlation study (Karl Pearsons) of the whole database including mild cases and those with no OSA (marked as AHI = 0) did not show any correlation between increasing BMI and severity of OSA (r = 0.0014). A similar study of the different break-up of BMI groups was not done in lieu of smaller numbers and the whole pool having not shown any correlation in the first place. It can thus be noted that a rising BMI does not necessarily imply a higher AHI.

Moreover, unlike other studies which used selective criteria before ordering polysomnography, all our patients were referred for this investigation. Also, the criteria that we used for diagnosis of sleep apnoea were very rigid. Scoring systems may help to highlight those patients at high risk of having OSA, but we believe that this is not a substitute for full overnight polysomnography reported by a pulmonologist. Polysomnography allows sleep apnoea to be accurately diagnosed and treatment recommendations to be given. Although this study can cause a delay in the patient's surgical procedure and may cause extra costs, we believe that this is a necessary step in the evaluation of co-morbidities before bariatric surgery. The treatment in diagnosed cases is a continuous positive airway pressure (CPAP) mask usage for a period of 1 month prior to surgery. This practice is followed in many bariatric surgical centres worldwide. This is believed by many to reduce the morbidity associated with general anaesthesia and surgery, particularly laparoscopic surgery in moderate to severe cases. The cut off value followed by many centres to recommend CPAP usage is an AHI of 25. The authors acknowledge that this remains an unclear and controversial part of bariatric surgical practice and some clinical research is warranted prior to making clinical guidelines.

In conclusion, until we have a reliable method to predict the presence of OSA, we recommend routine overnight polysomnography before bariatric surgery in all patients, regardless of BMI.

This study demonstrates improvement in sleep architecture in addition to a reduction in AHI, in association with weight loss. After the set target weight loss of 20 kg and 1 year post-procedure, AHI showed an average improvement of 50%, with a cure of OSA (AHI <5) in many preoperatively severe cases in the repeat studies pool (P <0.001). When we used a cut off of AHI 25 and above to recommend CPAP, 3 patients out of 17 continue to require CPAP, thus suggesting that detecting OSA preoperatively does have a bearing on overall patient management as up to 9% of patients will continue to require CPAP even after a cure rate of as high as 78%. There was a significant increase in the percentage of REM sleep and in the percentage of deeper stages of sleep (stage 3). Similar changes have been described earlier.[30]

This study differs from most previous studies. It has shown positive associations with some clinical factors having a higher incidence of being associated with OSA, namely male sex, higher BMI and the presence of hypertension. We believe that this can serve as a checklist to predict significant OSA in bariatric surgical practice across Asia. The most striking difference is that it has shown a higher cure rate of patients with significant OSA in the Asian population (78%), whereas most Western literature suggests lesser improvement rates and cure rates of about 4%.[31-33] One weakness of this study can be the choice of 20 kg cut off for eligibility in the study pool as it has been held at 30 kg in other studies from the West. We consider 20 kg over a 1 year period a significantly proportional figure in the smaller Asian patient.

In summary we can conclude that OSA is very common in severely obese Asians and its severity is difficult to assess thus justifying routine polysomnograms. Its severity does not co-relate with increasing BMI making a polysomnogram mandatory. There is no single factor to predict the absence of OSA. The Chinese have the lowest incidence of severe obesity, but the highest incidence of severe OSA. Up to about 46% of patients will require CPAP. Improvement following weight loss in Asians is more dramatic than in the Western world. This study is unique in that it estimates the true incidence of OSA in patients chosen for bariatric surgery in Asia and in terms of its findings which are quite different from that reported from the Western world.

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