




RESEARCH ARTICLE

**REVISED** Monitoring respiration and oxygen saturation in patients during the first night after elective bariatric surgery: A cohort study [version 2; referees: 2 approved]

Liselott Wickerts<sup>1,2</sup>, Sune Forsberg<sup>3,4</sup>, Frederic Bouvier<sup>5</sup>, Jan Jakobsson <sup>6</sup>

<sup>1</sup>Department of Anaesthesia, Norrtälje hospital, TioHundra AB, Norrtälje, Sweden

<sup>2</sup>Department of Clinical Sciences, Karolinska Institutet, Danderyd Hospital, Stockholm, Sweden

<sup>3</sup>Department of Anaesthesiology and Intensive Care, Norrtälje Hospital, Norrtälje, Sweden

<sup>4</sup>Department of Clinical Science and Education, Södersjukhuset, Karolinska Institutet, Stockholm, Sweden

<sup>5</sup>Norrtälje hospital, TioHundra AB, Norrtälje, Sweden

<sup>6</sup>Department of Anaesthesia and Intensive Care, Institution for Clinical Sciences, Karolinska Institutet, Danderyd Hospital, Stockholm, Sweden

**v2** First published: 22 May 2017, 6:735 (doi: [10.12688/f1000research.11519.1](https://doi.org/10.12688/f1000research.11519.1))  
 Latest published: 23 Jun 2017, 6:735 (doi: [10.12688/f1000research.11519.2](https://doi.org/10.12688/f1000research.11519.2))

**Abstract**

**Background:** Obstructive sleep apnoea and obese hypoventilation is not uncommon in patients with obesity. Residuals effect from surgery/anaesthesia and opioid analgesics may worsen respiration during the first nights after bariatric surgery. The aim of this observational study was to monitor respiration on the first postoperative night following elective bariatric surgery.

**Methods:** This observational study aimed to determine the incidence and severity of hypo/apnoea in low risk obese patients undergoing elective bariatric surgery in general anaesthesia. Patients with known or suspected sleep respiratory disturbances was not included. ESS was scored prior to surgery. Oxygen desaturation was analyzed by continuous respiratory monitoring. Mean oxygen saturation (SpO2), nadir SpO2, apnoea/hypopnea index and oxygen desaturation index was assessed by standard tools.

**Results:** 45 patients were monitored with portable polygraphy equipment (Embletta, ResMed) during the first postoperative night at the general ward following elective laparoscopic bariatric surgery. The prop ESS was 0-5 in 22, 6-10 in 14 and 11-16 in 6 of the patients studied (missing data 3). Mean SpO2 was 93%; 10 patients had a mean SpO2 of less than 92% and 4 of less than 90%. The lowest mean SpO2 was 87%. There were 16 patients with a nadir SpO2 of less than 85%, lowest nadir SpO2 being 63%. An Apnoea Hypo/apnoea Index (AHI) > 5 was found in 2 patients only (AHI 10 and 6), and an Oxygen Desaturation index (ODI) > 5 was found in 3 patients (24, 10 and 6, respectively). 3 patients had more prolonged (> 30 seconds) apnoea with nadir SpO2 81%, 83% and 86%. ESS score and type of surgery did not impact on respiration/oxygenation during the observation period.

**Conclusions:** A low mean SpO2 and episodes of desaturation were not uncommon during the first postoperative night following elective bariatric surgery in patients without history of night time breathing disturbance. AHI and/or ODI of more than 5 were only rarely seen. Night-time respiration monitoring provided seemingly sparse additional information. Further studies

**Open Peer Review**

Referee Status: 

	Invited Referees	
	1	2
<b>REVISED</b>		
<b>version 2</b>	report	report
published 23 Jun 2017		
<b>version 1</b>		
published 22 May 2017	report	report

- Peter N. Benotti**, Geisinger Medical Center, USA
- Frances Chung**, Department of Anesthesia, University of Toronto, Canada  
**Jean Wong**, Toronto Western Hospital, Canada

**Discuss this article**

Comments (2)

are need to assess risk factors and potential impact of the desaturation episodes that occurs during sleep.

**Corresponding author:** Jan Jakobsson ([jan.jakobsson@ki.se](mailto:jan.jakobsson@ki.se))

**Author roles:** **Wickerts L:** Conceptualization, Data Curation, Project Administration; **Forsberg S:** Conceptualization, Funding Acquisition, Methodology; **Bouvier F:** Methodology, Resources, Supervision; **Jakobsson J:** Conceptualization, Data Curation, Formal Analysis, Funding Acquisition, Methodology, Project Administration, Resources, Software, Supervision, Validation, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing

**Competing interests:** No competing interests were disclosed.

**How to cite this article:** Wickerts L, Forsberg S, Bouvier F and Jakobsson J. **Monitoring respiration and oxygen saturation in patients during the first night after elective bariatric surgery: A cohort study [version 2; referees: 2 approved]** *F1000Research* 2017, 6:735 (doi: [10.12688/f1000research.11519.2](https://doi.org/10.12688/f1000research.11519.2))

**Copyright:** © 2017 Wickerts L *et al.* This is an open access article distributed under the terms of the [Creative Commons Attribution Licence](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. Data associated with the article are available under the terms of the [Creative Commons Zero "No rights reserved" data waiver](#) (CC0 1.0 Public domain dedication).

**Grant information:** Financial support was obtained from the research department at TioHundra Norrtälje.

*The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.*

**First published:** 22 May 2017, 6:735 (doi: [10.12688/f1000research.11519.1](https://doi.org/10.12688/f1000research.11519.1))

**REVISED Amendments from Version 1**

The paper has been amended/revised extensively. The referees provided important and most adequate comments. The Method section has been revised, describing exclusion criteria, method for assessing breathing abnormalities. The Result section has been revised taking the preoperative ESS score into account and also providing additional analysis based on the ESS. Table 3, presenting the findings of respiration and oxygenation in relation to preoperative ESS score, has been added to the Results section. The Discussion is amended and the potential risks are further addressed. The Conclusion is revised stressing the need for further studies.

**See referee reports**

## Introduction

Obesity is on the increase in the western world and is associated with the development of several diseases. It is a major risk factor for cardiovascular disease and diabetes, two of the leading causes of death globally. Many efforts have been made in trying to treat the condition (<http://www.who.int/mediacentre/factsheets/fs311/en/>). The adverse effects on pulmonary function are also well documented<sup>1</sup>. With an increasing BMI, the risk for chronic daytime hypoventilation escalates, characterized by an arterial carbon dioxide pressure (PCO<sub>2</sub>) exceeding 45 mmHg<sup>1</sup>. Complications include atelectasis, hypoxemia, pulmonary embolism and subsequent acute ventilation failure, and may evolve during perioperative and postoperative phases<sup>1</sup>. Adverse effects are not concentrated to daytime; obesity is the most frequent predisposing factor of obstructive sleep apnoea syndrome (OSAS)<sup>1</sup>. Changes in the breathing pattern and pulmonary function may indeed cause compromise of oxygenation and increased risk for oxygen desaturation.

The early postoperative period with residual anaesthetic and analgesic effects may put an obese patient that has just undergone a laparoscopic bariatric procedure at risk for respiratory compromise. It has been debated whether early care should be carried out in a high dependency ward or could be safely done in a general ward.

The present study aimed to monitor first postoperative night respiration, breathing patterns and oxygenation with sleep breathing equipment, in patients having undergone elective laparoscopic bariatric surgery. We wanted to assess whether we could define risk factors associated with hypo/apnoea and desaturation episodes.

## Methods

This is an explorative cohort study; the study protocol was approved by the ethical committee at Karolinska Institutet [Dnr 2015/118 – 31/1 La]. Patients were included in the study after having provided verbal and written informed consent. Patients with known sleep related respiratory disturbances, diagnosed or suspected obstructive sleep apnoea was excluded.

Each patient filled out a questionnaire to determine if there was a suspicion of OSAS preoperatively; the questionnaire included

the Epworth Sleepiness Scale (ESS). Patients were monitored after surgery from 10 pm during the first postoperative night, until 6 am the next morning, with a portable OSAS breathing pattern monitor Embletta (ResMed). The registration included information about airflow from a nasal cannula, thoracic respiratory movements by an elastic band around the thorax and percutaneous O<sub>2</sub> saturation and heart rate from a pulse oximeter.

Apnoea was classified in accordance to the American Academy of Sleep Medicine (AASM) as a drop in the peak signal excursion by  $\geq 90\%$  of pre-event baseline air flow signal. The duration of the  $\geq 90\%$  drop in sensor signal must be  $\geq 10$  seconds. Hypopnea was classified by as a drop in the peak signal excursion by  $\geq 30\%$  of pre-event baseline. The duration of the  $\geq 30\%$  drop in signal excursions must be  $\geq 10$  seconds (Berry *et al.*, 2012)<sup>2</sup>.

All patients had anaesthesia and postoperative pain management in accordance to the routines of the department. All patients received premedication with 2 tablets of slow release 655mg paracetamol and 10 mg slow release oral oxycodone prior to surgery. Patients were preoxygenated by FiO<sub>2</sub> 1.0 and by CPAP of 6 cm H<sub>2</sub>O in the anaesthetic machine Aisys (GE Healthcare). Anaesthesia was induced with remifentanyl target control infusion (TCI), set at a target of 6.0 ng/ml. After 90 seconds the patient was put to sleep with a bolus injection of propofol 2–3 mg/kg. When the patient got apnoeic the ventilation mode was changed to pressure control ventilation-volume guaranteed (PCV-VG), and the patient received neuromuscular blocker rocuronium, followed by endotracheal intubation. Anaesthesia was maintained with sevoflurane and remifentanyl titrated to clinical signs of adequate anaesthesia, and with a BIS (Medtronic, Covidien BIS LoC 2 Channel) value between 25 and 50. All patients received postoperative nausea and vomiting (PONV) prophylaxis with betamethasone, ondansetron and droperidol. 10 – 15 mg of morphine was administered at the beginning of surgery, as a start dose for the postoperative pain relief regime. The patient had laparoscopic surgery, gastric bypass or sleeve gastrectomy, as decided by the surgeon. Postoperative care was provided in accordance to routines; fentanyl 25–50 micrograms was used as rescue analgesia and a further 1–5 mg morphine administered as needed. Postoperative respiratory care included oxygen supplementation to satisfactory saturation and once per hour blowing in a T-piece with a one-way valve mouthpiece (Intersurgical). Patients were transferred to the general ward when fully awake and with stable vital signs for 30 minutes. No intervention was done apart from the night breathing monitoring.

## Statistics

All data is presented as mean and standard deviation. The breathing data was evaluated in accordance to standard assessment,

- the AHI was calculated as hypo and/or apnoea/hour
- the ODI was calculated as oxygen saturation decrease of  $> 4$  for 30 seconds/hour

## Results

There were 52 patients initially included in the study, but 6 were excluded as they had a diagnosis of OSAS and 1 further patient was

excluded as the procedure became merely a diagnostic laparoscopy. Forty-five patients were included in the study.

The mean age for the 45 patients studied was 39 (ranging from 19 – 68 years), and the mean BMI was 37 (ranging from 32 – 53). The preoperative ESS scale screening showed that 22 of our patients had an ESS 0-5, 14 had a score of 6 – 10 and 6 patients had ESS of more than 10. Highest ESS was 16 in one 26 year old female patient with a BMI of 41.

Surgery and anaesthesia was uneventful, mean duration of surgery was 54 minutes (ranging from 27 – 97 minutes) and mean duration of anaesthesia was 108 (ranging from 65 – 217 minutes). Most patients (n=35), had a sleeve gastrectomy and 10 had a gastric bypass procedure.

Mean time between end of anaesthesia and start of the polygraphy was 611 ± 122 minutes and mean duration of polygraphy monitoring was 463 ± 51 minutes.

Mean saturation (SpO<sub>2</sub>) during the polygraphy was 93% (ranging from 87 – 97). There were 10 patients with a mean SpO<sub>2</sub> of less than 92% and 4 with mean of less than 90, with the lowest mean SpO<sub>2</sub> being 87%. There were 16 patients with a nadir SpO<sub>2</sub> of less than 85%, lowest nadir SpO<sub>2</sub> being 63%.

Only 2 patients had an AHI > 5; (AHI 10 and 6). Both underwent sleeve gastrectomy. They also had an ODI > 5 (10 and 24, respectively). These patients had mean saturation 88% and 91% during the registration and SpO<sub>2</sub> nadir of 79% and 81%.

In total, 3 patients had an ODI > 5 (24, 10 and 6, respectively). Additionally, 3 patients had more prolonged (> 30 second) apnoea with nadir SpO<sub>2</sub> 81%, 83% and 86%.

Changes in respiration and oxygenation did not differ between the 3 ranges of ESS scores, see Table 1.

We could further not see any difference apart from a shorter duration of anaesthesia between the surgical procedures (See Table 2 and Table 3)

**Table 1. Demographics for the patients studied; mean ± SD.** GBP: gastric bypass; Sleeve: sleeve gastrectomy; f: female; m: male.

	GBP n=10	Sleeve n=35
Age (years)	37 ± 15	49 ± 13
Gender (f/m)	9/1	30/5
BMI	36 ± 3	37 ± 5

**Table 2. Main findings; mean ± SD.** GBP: gastric bypass; Sleeve: sleeve gastrectomy.

	GBP n=10	Sleeve n=35
Duration of anaesthesia <i>min.</i>	125 ± 20	103 ± 29 *
Duration of Surgery <i>min.</i>	63 ± 16	51 ± 18
Duration in the PACU <i>min.</i>	308 ± 89	355 ± 197
Time until start of registration <i>min.</i>	615 ± 129	609 ± 121
Duration of registration <i>min.</i>	461 ± 41	463 ± 55
Mean SpO <sub>2</sub>	93.1 ± 3.0	92.8 ± 2.1
Nadir SpO <sub>2</sub>	85.3 ± 9	84.3 ± 6
Max duration nadir SpO <sub>2</sub>	3 ± 7	9 ± 25
AHi	0.1 ± 0.3	0.7 ± 2
ODi	0.1 ± 0.3	1.5 ± 4.5

**Table 3. Respiration and oxygenation in relation to the preoperative ESS score.**

	ESS 0-5 (n=22)	ESS 6-10 (n=14)	ESS > 10 (n=6)
Age (years)	36 ± 13	40 ± 10	43 ± 18
BMI	35 ± 5	36 ± 4	38 ± 3
Mean SpO <sub>2</sub>	92 ± 2.4	93 ± 2.1	93 ± 1.9
Nadir SpO <sub>2</sub>	85 ± 6.1	84 ± 9.5	84 ± 5.1
AHi	0.7 ± 2.3	0.1 ± 0.4	0.2 ± 0.4
ODi	1.7 ± 5.3	0.4 ± 1.1	0

The one patient with an ESS of 16 did not show and hypo or apnoeas during the observation period, and had a mean SpO<sub>2</sub> of 92 and nadir SpO<sub>2</sub> of 79%.

**Dataset 1. Raw sleep monitoring data from 45 patients that was used as a basis for the findings in this study**

<http://dx.doi.org/10.5256/f1000research.11519.d161775>

## Discussion

We found, somewhat surprisingly, only very minor respiratory disturbances in the cohort of patients having undergone elective bariatric surgery. No patients had a hypopnea index above thirty - only 2 had an AHI above 5. A majority of patients had low oxygen saturation of around 93%, and short episodes of saturation below 85% were not uncommon. Thus, the main finding is mild hypoxia and episodes of desaturation, but hypo/apnoea monitoring does not provide much additional information. Signs of more pronounced airway compromise causing hypo/apnoea were only rarely seen.

Low mean saturation and desaturation episodes were however not uncommon. The preoperative ESS score did not help predict differences in oxygenation. All our patients had no further complications.

The risk for postoperative hypoxia has been known for long. Jones *et al.* published a review in 1990 addressing the risk for low oxygenation during the early postoperative period, and its multifactorial etiology<sup>3</sup>. Low saturation and mild hypoxia has also been reported in previous studies and the risk in bariatric surgery must be acknowledged<sup>4</sup>.

We are not aware of any previous study explicitly monitoring hypo/apnoea during the first postoperative night after bariatric surgery. Zaremba *et al.* studied polysomnography in patients during the early postoperative course, while patients were still in the PACU<sup>5</sup>. They found that 64% of the 33 patients with complete postoperative polysomnography data had signs of sleep-disordered breathing with an AHI greater than 5/h early after recovery from anaesthesia. The respiratory response to hypoxia and hypercapnia caused by airway obstruction is compromised following major surgery<sup>6</sup>. Chung *et al.* studied respiration during the preoperative stage and the first, second and third postoperative nights<sup>7</sup>. Our results are in line with these results, first night after surgery. Female patients and patients with no or mildly compromised nocturnal breathing showed only minor changes during the first postoperative night in Chung *et al.*'s study as well as in ours. Age, preoperative respiration disturbance and smoking were found to be risk factors for hypo/apnoea<sup>8</sup>.

We used a standard portable breath and saturation monitor, the Embletta system. The portable systems have been shown to be accurate tool for assessment of sleep apnoea<sup>9</sup>. We did not include EEG monitoring and we did not attach the abdominal movement tracing. Merely the nasal flow, thoracic and saturation was recorded. AHI scores were > 5 for mild, > 15 for intermediate and > 30 for significant airway compromise, or "sleep apnoea". We assessed SpO<sub>2</sub> < 94 as mild hypoxia. The monitoring was initiated during the first evening, an average of ten hours after the end of anaesthesia. It should also be acknowledged that the mean BMI in our cohort was 37, versus a mean BMI of 44 in the US studies<sup>5</sup>.

Nocturnal oxygen desaturations are not uncommon during the first postoperative night, also in patients undergoing other surgical procedures. Shirmakana *et al.* found that oxygen desaturation was frequent in patients having undergone breast surgery<sup>10</sup>. Bowdle looked at a mixed group of ambulatory surgery patients and also found an increase in hypo/apnoea and desaturation in the first night after surgery<sup>11</sup>.

There are recent guidelines from the US association for sleep apnoea<sup>12</sup>. Germany has also addressed the importance of adequate

perioperative care of obese patients at risk for sleep apnoea<sup>13</sup>. The preoperative evaluation by registration of hypo/apnoea is strongly recommended, however advice given around the early postoperative period is sparse. The ESS should of course also be used for screening<sup>14</sup>. The vast majority of our patient had a "normal" ESS, and group of patients with an ESS above 10 was small and did not provide any firm additional information.

To put our findings into perspective, our patients had a mean BMI of merely 37. Additionally, we had a majority (39 out of 45) of female patients, and BMI-associated AHI abnormalities are more commonly seen in males<sup>15</sup>. The physical status, muscle strength and breathing capacity was not assessed or screened preoperatively. We did not use the abdominal movement monitoring band to avoid additional abdominal pain. All patients had multi-modal analgesia and opioids were administered as restrictively as possible to maintain adequate pain control. There is an obvious need for further studies looking for risk factors and also better determine potential risks associated to the desaturation episodes that are not uncommonly noticed.

In conclusion, we have found that elective "low risk" obese patients that have had uncomplicated laparoscopic bariatric surgery, have low saturation during the first postoperative night and may experience episodes of oxygen saturation of less than 85%, but hypo/apnoea is rare and monitoring of obstruction seems not to be of major value. The potential clinical impact of the mild hypoxia and short episodes of desaturations requires further study.

We have followed the [STROBE guidelines](#).

### Data availability

**Dataset 1. Raw sleep monitoring data from 45 patients that was used as a basis for the findings in this study.** DOI, [10.5256/f1000research.11519.d161775](https://doi.org/10.5256/f1000research.11519.d161775)<sup>16</sup>

### Author contributions

JJ and SF were in charge of the study design protocol and processed applications. LW and SF had major roles in patient recruitment and collection of study data. All authors contributed equally to data analysis and manuscript preparation.

### Competing interests

No competing interests were disclosed.

### Grant information

Financial support was obtained from the research department at TioHundra Norrtälje.

*The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.*

## References

1. Koenig SM: **Pulmonary complications of obesity.** *Am J Med Sci.* 2001; **321**(4): 249–79.  
[PubMed Abstract](#) | [Publisher Full Text](#)
2. Berry RB, Budhiraja R, Gottlieb DJ, *et al.*: **Rules for scoring respiratory events in sleep: update of the 2007 AASM Manual for the Scoring of Sleep and Associated Events. Deliberations of the Sleep Apnea Definitions Task Force of the American Academy of Sleep Medicine.** *J Clin Sleep Med.* 2012; **8**(5): 597–619.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
3. Jones JG, Sapsford DJ, Wheatley RG: **Postoperative hypoxaemia: mechanisms and time course.** *Anaesthesia.* 1990; **45**(7): 566–73.  
[PubMed Abstract](#) | [Publisher Full Text](#)
4. Gallagher SF, Haines KL, Osterlund LG, *et al.*: **Postoperative hypoxemia: common, undetected, and unsuspected after bariatric surgery.** *J Surg Res.* 2010; **159**(2): 622–6.  
[PubMed Abstract](#) | [Publisher Full Text](#)
5. Zarembo S, Shin CH, Hutter MM, *et al.*: **Continuous Positive Airway Pressure Mitigates Opioid-induced Worsening of Sleep-disordered Breathing Early after Bariatric Surgery.** *Anesthesiology.* 2016; **125**(1): 92–104.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
6. Nieuwenhuijs D, Bruce J, Drummond GB, *et al.*: **Ventilatory responses after major surgery and high dependency care.** *Br J Anaesth.* 2012; **108**(5): 864–71.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
7. Chung F, Liao P, Elsaid H, *et al.*: **Factors associated with postoperative exacerbation of sleep-disordered breathing.** *Anesthesiology.* 2014; **120**(2): 299–311.  
[PubMed Abstract](#) | [Publisher Full Text](#)
8. Chung F, Liao P, Yang Y, *et al.*: **Postoperative sleep-disordered breathing in patients without preoperative sleep apnea.** *Anesth Analg.* 2015; **120**(6): 1214–24.  
[PubMed Abstract](#) | [Publisher Full Text](#)
9. Gjevre JA, Taylor-Gjevre RM, Skomro R, *et al.*: **Comparison of polysomnographic and portable home monitoring assessments of obstructive sleep apnea in Saskatchewan women.** *Can Respir J.* 2011; **18**(5): 271–4.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
10. Shirakami G, Teratani Y, Fukuda K: **Nocturnal episodic hypoxemia after ambulatory breast cancer surgery: comparison of sevoflurane and propofol-fentanyl anesthesia.** *J Anesth.* 2006; **20**(2): 78–85.  
[PubMed Abstract](#) | [Publisher Full Text](#)
11. Bowdle TA: **Nocturnal arterial oxygen desaturation and episodic airway obstruction after ambulatory surgery.** *Anesth Analg.* 2004; **99**(1): 70–6.  
[PubMed Abstract](#) | [Publisher Full Text](#)
12. Chung F, Memtsoudis SG, Ramachandran SK, *et al.*: **Society of Anesthesia and Sleep Medicine Guidelines on Preoperative Screening and Assessment of Adult Patients With Obstructive Sleep Apnea.** *Anesth Analg.* 2016; **123**(2): 452–73.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
13. Fassbender P, Herbstreit F, Eikermann M, *et al.*: **Obstructive Sleep Apnea-a Perioperative Risk Factor.** *Dtsch Arztebl Int.* 2016; **113**(27–28): 463–9.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
14. Raaff CAL, Gorter-Stam MAW, de Vries N, *et al.*: **Perioperative Management of Obstructive Sleep Apnea in Bariatric Surgery: a Consensus Guideline.** *Surg Obes Rel Dis.* (in press).  
[Publisher Full Text](#)
15. Lumachi F, Marzano B, Fanti G, *et al.*: **Relationship between body mass index, age and hypoxemia in patients with extremely severe obesity undergoing bariatric surgery.** *In Vivo.* 2010; **24**(5): 775–7.  
[PubMed Abstract](#)
16. Wickerts L, Forsberg S, Bouvier F, *et al.*: **Dataset 1 in: Monitoring respiration and oxygen saturation in patients during the first night after elective bariatric surgery: A cohort study.** *F1000Research.* 2017.  
[Data Source](#)

# Open Peer Review

Current Referee Status:  

---

## Version 2

Referee Report 31 July 2017

doi:[10.5256/f1000research.12973.r23753](https://doi.org/10.5256/f1000research.12973.r23753)



**Frances Chung**

University Health Network, Toronto Western Hospital, Department of Anesthesia, University of Toronto, Toronto, ON, Canada

We are happy with the revisions.

**Competing Interests:** No competing interests were disclosed.

**I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.**

Referee Report 06 July 2017

doi:[10.5256/f1000research.12973.r24052](https://doi.org/10.5256/f1000research.12973.r24052)



**Peter N. Benotti**

Geisinger Obesity Institute, Geisinger Medical Center, Danville, PA, USA

I have reviewed the revised submission and feel the authors have addressed all of my comments in a satisfactory manner.

**Competing Interests:** No competing interests were disclosed.

**I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.**

---

## Version 1

Referee Report 20 June 2017

doi:[10.5256/f1000research.12443.r23655](https://doi.org/10.5256/f1000research.12443.r23655)



**Frances Chung**<sup>1</sup>, **Jean Wong**<sup>2</sup>

<sup>1</sup> University Health Network, Toronto Western Hospital, Department of Anesthesia, University of Toronto,

Toronto, ON, Canada

<sup>2</sup> University Health Network, Toronto Western Hospital, Toronto, ON, Canada

This observational study sought to determine the incidence and severity of hypopnea or apnea on the first night after surgery, in patients who did not have a diagnosis of OSA undergoing elective laparoscopic bariatric surgery. They monitored 45 patients with a portable polygraphy during the first postoperative night. They report that oxygen desaturation and short episodes of desaturation occurred in some patients, but there were few patients with an AHI or ODI greater than five. They conclude that respiratory monitoring for low risk patients on the general ward provides little additional information.

Although this is an interesting study, this manuscript can be improved by providing more details in the Methods and Results. In the Introduction, the authors state that they wished to assess risk factors associated with hypopnea or apnea and desaturation. However, the presence of co-morbidities is not mentioned and there is no analysis of the risk factors that were associated with the patients that experienced desaturation/apnea/hypopnea. The questionnaire that was used to determine the risk of OSAS is indicated to be Epworth Sleepiness scale. The validation of this scale to screen for sleep apnea is relatively modest. It is not clear whether patients with obstructive sleep apnea are excluded from the study after use of questionnaire. Is sleep apnea one of the exclusion criteria of the study? The results of the questionnaire to determine risk of OSAS should be reported, it is unclear whether the patients who participated in the study were at low risk or may be at risk or have undiagnosed OSAS.

The definition of apnea/hypopnea should be stated. The explanation for the sample size should be added. The number of patients receiving oxygen on the ward should be added, especially as it is mentioned in the methods section that patients received oxygen supplementation postoperatively. In Tables 1 and 2, the authors compare gastric bypass vs. sleeve gastrectomy, however, the authors have not stated whether they expected a difference between these 2 groups. There are some grammatical errors in the manuscript.

**Is the work clearly and accurately presented and does it cite the current literature?**

Partly

**Is the study design appropriate and is the work technically sound?**

Partly

**Are sufficient details of methods and analysis provided to allow replication by others?**

Partly

**If applicable, is the statistical analysis and its interpretation appropriate?**

Partly

**Are all the source data underlying the results available to ensure full reproducibility?**

Partly

**Are the conclusions drawn adequately supported by the results?**

Partly

**Competing Interests:** No competing interests were disclosed.



**We have read this submission. We believe that we have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however we have significant reservations, as outlined above.**

Author Response ( *Member of the F1000 Faculty and F1000Research Advisory Board Member* ) 20 Jun 2017

**Jan Jakobsson**, Department of Physiology and Pharmacology, Karolinska Institutet, Sweden

Dear referee,

Thank you for review and most appreciated/important comments:

Patients with known sleep related respiratory disturbances, diagnosed or suspected obstructive sleep apnea was excluded.

We used the ESS scale for screening, 22 of our patients had an ESS 0-5, 14 had a score of 6 – 10 and 6 patients had ESS of more than 10. Highest ESS was 16 in one 26 year old female patient with a BMI of 41. She had a mean SpO<sub>2</sub> of 92% and a nadir SpO<sub>2</sub> of 79. She did not show and hypo or apneas during the observation period. There are 3 patients where ESS is missing.

Apnea was classified in accordance to the American Academy of Sleep Medicine (AASM) as a drop in the peak signal excursion by  $\geq 90\%$  of pre-event baseline air flow signal. The duration of the  $\geq 90\%$  drop in sensor signal must be  $\geq 10$  seconds. Hypopnea was classified by as a drop in the peak signal excursion by  $\geq 30\%$  of pre-event baseline. The duration of the  $\geq 30\%$  drop in signal excursions must be  $\geq 10$  seconds (Berry *et al* 2012).

Berry RB, Budhiraja R, Gottlieb DJ, Gozal D, Iber C, Kapur VK, *et al*. Rules for scoring respiratory events in sleep: update of the 2007 AASM Manual for the Scoring of Sleep and Associated Events. Deliberations of the Sleep Apnea Definitions Task Force of the American Academy of Sleep Medicine. *J Clin Sleep Med*. American Academy of Sleep Medicine; 2012 Oct 15;8(5):597–619.

We have analysed the results also taking the ESS into account, but we failed to see any clear association between ESS and respiration/saturation see Table 3

Table 3

ESS 0-5

(n=22)

ESS 6-10

(n=14)

ESS > 10

(n=6)

Age (years)

36  $\pm$  13

40  $\pm$  10

43  $\pm$  18

BMI

35  $\pm$  5

36  $\pm$  4

38  $\pm$  3

Mean SpO<sub>2</sub>

92  $\pm$  2.4

93 ± 2.1

93 ± 1.9

Nadir SpO<sub>2</sub>

85 ± 6.1

84 ± 9.5

84 ± 5.1

AHi

0.7 ± 2.3

0.1 ± 0.4

0.2 ± 0.4

ODi

1.7 ± 5.3

0.4 ± 1.1

0

We did not know whether surgical procedure had an impact and therefore tested also for surgical technique.

We hope that these responses is in line with your expectations, an update manuscript is on the way.

Best regards

Jan Jakobsson, on behalf of the authors

**Competing Interests:** No competing interests were disclosed.

Referee Report 20 June 2017

doi:[10.5256/f1000research.12443.r23609](https://doi.org/10.5256/f1000research.12443.r23609)



**Peter N. Benotti**

Geisinger Obesity Institute, Geisinger Medical Center, Danville, PA, USA

Hypoxemia in the immediate postoperative period is a well-known and feared complication after bariatric surgery. Risk factors for hypoxemia include patient age (likely because of the increase in closing volume with aging), loss of lung volume during induction and maintenance of general anesthesia, alterations in respiratory drive related to general anaesthetics and use of opiates, as well as the the presence of obstructive sleep apnea.<sup>1,2</sup> The exact incidence of hypoxemia and hypercarbia after bariatric surgery has not been well studied, but several studies in relatively small numbers of patients have documented worrisome levels of hypoxemia.<sup>2,3</sup>

Wickerts and co-workers<sup>4</sup> have studied 45 good risk bariatric surgery patients. The mean age of the cohort was 39, the mean BMI was 37, and patients with known Obstructive Sleep Apnea were excluded. They all underwent uncomplicated and brief laparoscopic foregut procedures for obesity and were studied for 8 hours with pulse oximetry during the first postoperative night. Study findings included 22% with a

mean SaO<sub>2</sub> < 92%, 9% with mean SaO<sub>2</sub> < 90% (lowest mean SaO<sub>2</sub> was 87%), and 36% with nadir SaO<sub>2</sub> < 85% (lowest nadir SaO<sub>2</sub> was 63%). In addition, sleep disordered breathing events were documented in several patients. No clinical events related to hypoxia or sleep disordered breathing are recorded.

These findings are important as because they do document a small, but significant risk of potentially dangerous postoperative hypoxia even in low risk patients. Recently published guidelines recommend continuous monitoring with pulse oximetry in the early postoperative period.<sup>4</sup> Guidelines for perioperative management of low risk patients as studied here are lacking.

Additional studies of the epidemiology of perioperative hypoxemia and hypercarbia complicating bariatric surgery are needed in order to begin to identify potentially modifiable patient-specific risk factors and interventions such as inspiratory muscle training<sup>3</sup> which might reduce the risks of this potentially dangerous problem. The authors are encouraged to continue this survey and attempt to relate hypoxemia to risk factors. In addition, continued studies to include EKG monitoring with pulse oximetry might add to the clinical significance of these findings. The authors comment that the observed episodes of desaturation were brief, but they do not share any data regarding the duration of desaturations. I would be concerned about the possible clinical impact of 30 seconds of apnea in an unmonitored setting on the initial post operative night following bariatric surgery

In this era of cost constraints and limited patient access to bariatric surgery, cost reduction strategies designed to encourage same day bariatric surgery procedures are popular. Improved ability to recognize and address risk factors for postoperative hypoxemia should be an important component of the selection process for accelerated care.

The phrase that “hypoxia not only stops the engine, but destroys the machinery” has been attributed to JBS Haldane. Case reports of respiratory arrest and sudden unexplained fatality after bariatric surgery suggest that he was correct.

## References

1. Lumachi F, Marzano B, Fanti G, Basso SM, Mazza F, Chiara GB: Relationship between body mass index, age and hypoxemia in patients with extremely severe obesity undergoing bariatric surgery. *In Vivo*. **24** (5): 775-7 [PubMed Abstract](#)
2. Gallagher SF, Haines KL, Osterlund LG, Mullen M, Downs JB: Postoperative hypoxemia: common, undetected, and unsuspected after bariatric surgery. *J Surg Res*. 2010; **159** (2): 622-6 [PubMed Abstract](#) | [Publisher Full Text](#)
3. Lloréns J, Rovira L, Ballester M, Moreno J, Hernández-Laforet J, Santonja FJ, Cassinello N, Ortega J: Preoperative inspiratory muscular training to prevent postoperative hypoxemia in morbidly obese patients undergoing laparoscopic bariatric surgery. A randomized clinical trial. *Obes Surg*. 2015; **25** (6): 1003-9 [PubMed Abstract](#) | [Publisher Full Text](#)
4. Raaff C.A.L, Gorter-Stam M.A.W, de Vries N, Sinha A.C, Bonjer H.J, Chung F, Coblijn U.K, Dahan A, van den Helder R.S, Hilgevoord A.A.J, Hillman D.R, Margaron M.P, Mattar S.G, Mulier J.P, Ravesloot M.J.L, Reiber B.M.M, van Rijswijk A, Singh P.M, Steenhuis R, Tenhagen M, Vanderveken O.M, Verbraecken J, White D.P, van der Wielen N, van Wagenveld B.A: Perioperative Management of Obstructive Sleep Apnea in Bariatric Surgery: a Consensus Guideline. *Surg Obes Rel Dis*. (in press). [Publisher Full Text](#)

## Is the work clearly and accurately presented and does it cite the current literature?

Partly

**Is the study design appropriate and is the work technically sound?**

Partly

**Are sufficient details of methods and analysis provided to allow replication by others?**

Yes

**If applicable, is the statistical analysis and its interpretation appropriate?**

Not applicable

**Are all the source data underlying the results available to ensure full reproducibility?**

Yes

**Are the conclusions drawn adequately supported by the results?**

Partly

**Competing Interests:** No competing interests were disclosed.

**I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.**

Author Response ( *Member of the F1000 Faculty and F1000Research Advisory Board Member* ) 20 Jun 2017

**Jan Jakobsson**, Department of Physiology and Pharmacology, Karolinska Institutet, Sweden

Dear Referee

Thank you for your important and constructive comments on our paper. Bariatric surgery do increase and enhanced recovery pathways are not uncommonly used. The aim of our study was to assess respiration/oxygenation in "low risk patients" undergoing elective laparoscopic "low risk bariatric surgery" and my expectation was indeed that we should observe more. Still agree even the observations found should be interpreted in a context; avoiding patient risk.

We did not monitor duration of desaturation unfortunately but the hypopnea time was registered and was in two patients prolonged. The portable device used did not log duration of desaturation. We did not monitor ECG and/or sign of myocardial ischemia. There were however no complaints of chest pain or any other signs/symptoms alerting us to suspect myocardial or other ischemic events.

We were in the group of patients not able to identify explicit risk factors.

The literature is extensive and we are more than happy to add suggested papers.

We are planning to continue our efforts looking at the first night respiratory events and will in these studies add ECG.

I hope this response can be seen as acceptable and further suggestions for future studies are most welcome.

Best regards  
Jan Jakobsson, on behalf of the authors

**Competing Interests:** No competing interests were disclosed.

---

## Discuss this Article

Version 1

Author Response ( *Member of the F1000 Faculty and F1000Research Advisory Board Member* ) 20 Jun 2017

**Jan Jakobsson**, Department of Physiology and Pharmacology, Karolinska Institutet, Sweden

Dear Mehran

Thank you for comments on our paper.

Please excuse the ignorance with the statistical software;  
*Data was analysed with StatView (v1.04) for MAC.*

There are of course limitations and we have tried to address some of them but we did not compile a specific strength and limitation section,

We studied low risk patients undergoing elective bariatric surgery in one center. All patients followed the same clinical pathway and was cared for by a limited number of physicians and nurses, thus perioperative care was standardized. We used a portable respiratory monitoring equipment so called Embletta. There are limitations with this technique and a more advanced polysomnography device would have been an option. We did not monitor ECG, and no other specific monitoring of potential ischemic episodes. We did not measure the carbon dioxide tension. A continuous transcutaneous carbon dioxide monitor could have been of interest.

I hope these brief lines can at least to some extent respond to your queries,

Best regards  
Jan Jakobsson on behalf of the authors.

**Competing Interests:** No competing interests were disclosed.

Reader Comment 25 May 2017

**Mehran Shams**, Non-Communicable Diseases Research Center, Endocrinology and Metabolism  
Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran

Dear Jakobsson

I have 2 comments for you:

1. In the Statistics section it is better to mention the software that you used for analysis.
2. In the Discussion section it is recommended that explain Limitations & strengths of your study.

Best Wishes

**Competing Interests:** No competing interests were disclosed.

---