RESEARCH ARTICLE

Monitoring respiration and oxygen saturation in patients during the first night after elective bariatric surgery: A cohort study [version 1; peer review: 2 approved with reservations]

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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/apnea. Oxygen desaturation was analysed by continuous respiratory monitoring. **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. 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/apnea 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%.

Conclusions: A low mean SpO₂ and short 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 sparse additional information. Thus, it seems reasonable to have low risk patients at general ward already in their first night after bariatric

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Approval Status

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1. **Peter N. Benotti**, Geisinger Medical Center, Danville, USA

2. **Frances Chung**, Department of Anesthesia, University of Toronto, Toronto, Canada
Jean Wong, Toronto Western Hospital, Toronto, Canada

Any reports and responses or comments on the article can be found at the end of the article.

surgery.

Keywords

obesity, bariatric surgery, general anaesthesia, postoperative polygraphy

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

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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 documented¹. With an increasing BMI, the risk for chronic daytime hypoventilation escalates, characterized by an arterial carbon dioxide pressure (PCO₂) exceeding 45 mmHg¹. Complications include atelectasis, hypoxemia, pulmonary embolism and subsequent acute ventilation failure, and may evolve during perioperative and postoperative phases¹. Adverse effects are not concentrated to daytime; obesity is the most frequent predisposing factor of obstructive sleep apnoea syndrome (OSAS)¹. 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/apnea 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. 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 O₂ saturation and heart rate from a pulse oximeter.

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 FiO₂ 1.0 and by CPAP of 6 cm H₂O 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 beta-methasone, 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). 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 (SpO₂) during the polygraphy was 93% (ranging from 87 – 97). There were 10 patients with a mean SpO₂ of less than 92% and 4 with mean of less than 90, with the lowest mean SpO₂ being 87%. There were 16 patients with a nadir SpO₂ of less than 85%, lowest nadir SpO₂ 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 SpO2 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 SpO2 81%, 83% and 86%.

We could not see any difference apart from a shorter duration of anaesthesia between the surgical procedures (See Table 1 and Table 2)

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>

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

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

Table 2. Main findings; mean $\pm$ SD. GBP: gastric bypass; Sleeve: sleeve gastrectomy.

	GBP n=10	Sleeve n=35
Duration of anaesthesia <i>min.</i>	125 $\pm$ 20	103 $\pm$ 29 *
Duration of Surgery <i>min.</i>	63 $\pm$ 16	51 $\pm$ 18
Duration in the PACU <i>min.</i>	308 $\pm$ 89	355 $\pm$ 197
Time until start of registration <i>min.</i>	615 $\pm$ 129	609 $\pm$ 121
Duration of registration <i>min.</i>	461 $\pm$ 41	463 $\pm$ 55
Mean SpO2	93.1 $\pm$ 3.0	92.8 $\pm$ 2.1
Nadir SpO2	85.3 $\pm$ 9	84.3 $\pm$ 6
Max duration nadir SpO2	3 $\pm$ 7	9 $\pm$ 25
AHI	0.1 $\pm$ 0.3	0.7 $\pm$ 2
ODi	0.1 $\pm$ 0.3	1.5 $\pm$ 4.5

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/apnea monitoring does not provide much additional information. Signs of more pronounced airway compromise causing hypo/apnea were only rarely seen. Low mean saturation and desaturation episodes were however not uncommon. 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 etiology². Low saturation and mild hypoxia has also been reported in previous studies.

We are not aware of any previous study explicitly monitoring hypo/apnea 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 PACU³. 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 surgery⁴. Chung *et al.* studied respiration during the preoperative stage and the first, second and third postoperative nights⁵. 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/apnea⁶.

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 apnoea⁷. 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 SpO2 < 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 studies³.

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 surgery⁸. Bowdle looked at a mixed group of ambulatory surgery patients and also found an increase in hypo/apnea and desaturation in the first night after surgery⁹.

There are recent guidelines from the US association for sleep apnoea¹⁰. Germany has also addressed the importance of adequate perioperative care of obese patients at risk for sleep apnoea¹¹. The preoperative evaluation by registration of hypo/apnea is strongly recommended, however advice given around the early postoperative period is sparse.

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 males¹². 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.

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 short episodes of oxygen saturation of less than 85%, but hypo/apnea 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)¹³

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

- Koenig SM: **Pulmonary complications of obesity.** *Am J Med Sci.* 2001; **321**(4): 249–79.
[PubMed Abstract](#) | [Publisher Full Text](#)
- Jones JG, Sapsford DJ, Wheatley RG: **Postoperative hypoxaemia: mechanisms and time course.** *Anaesthesia.* 1990; **45**(7): 566–73.
[PubMed Abstract](#) | [Publisher Full Text](#)
- Zaremba 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](#)
- 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](#) | [Free Full Text](#)
- 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](#)
- 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](#)
- 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](#)
- 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](#)
- 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](#)
- 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](#)
- 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](#)
- Ernst G, Bosio M, Salvado A, et al.: **Difference between apnea-hypopnea index (AHI) and oxygen desaturation index (ODI): proportional increase associated with degree of obesity.** *Sleep Breath.* 2016; **20**(4): 1175–1183.
[PubMed Abstract](#) | [Publisher Full Text](#)
- 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](#)

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Version 1

Reviewer Report 20 June 2017

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Frances Chung

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

Jean Wong

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 confirm that we have read this submission and 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 (F1000Research Advisory Board Member) 20 Jun 2017

Jan Jakobsson, Karolinska Institutet, Danderyd Hospital, Stockholm, 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 SpO₂ of 92% and a nadir SpO₂ 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 ≥ 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 ≥ 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 ± 13

40 ± 10

43 ± 18

BMI

35 ± 5

36 ± 4

38 ± 3

Mean SpO2

92 ± 2.4

93 ± 2.1

93 ± 1.9

Nadir SpO2

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.

Reviewer Report 20 June 2017

<https://doi.org/10.5256/f1000research.12443.r23609>

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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.^{1,2} 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.^{2,3}

Wickerts and co-workers⁴ 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 SaO₂ < 92%, 9% with mean SaO₂ < 90% (lowest mean SaO₂ was 87%), and 36% with nadir SaO₂ < 85% (lowest nadir SaO₂ 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.⁴ 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 is inspiratory muscle training³ 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, et al.: 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, et al.: 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, et al.: 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, et al.: 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 confirm that I have read this submission and 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 (F1000Research Advisory Board Member) 20 Jun 2017

Jan Jakobsson, Karolinska Institutet, Danderyd Hospital, Stockholm, 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 high 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.

Comments on this article

Version 1

Author Response (F1000Research Advisory Board Member) 20 Jun 2017

Jan Jakobsson, Karolinska Institutet, Danderyd Hospital, Stockholm, 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, 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.

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