THE ACCURACY OF NON-INVASIVE NASAL CAPNOGRAPHY IN MORBIDLY OBESE PATIENTS AFTER BARIATRIC SURGERY

ALEXANDRE YAZIGI*, CARINE ZEENI*, FREDA RICHA*,
VIVIANE CHALHOUB*, GHASSAN SLEILATY**
AND ROGER NOUN***

Abstract

Study objective to assess the accuracy of nasal capnography for the monitoring of ventilation in extubated morbidly obese patients, following bariatric surgery.

Design: prospective descriptive study.

Setting: Post-anesthesia care unit.

Patients: 25 consecutive morbidly obese patients admitted to the PACU after open bariatric surgery.

Intervention: Patients had a nasal cannula designed to administer oxygen (3 L/min) and to sample expired CO_2 by a coaxial catheter.

Measurements: Capnographic waveform, end-tidal CO_2 ($ETCO_2$) and respiratory rate (RRd) were displayed by a capnometer (Datex-Ohmeda). Arterial CO_2 pressure ($PaCO_2$) was measured by blood gas analysis. Respiratory rate was measured by visual inspection of chest breathing motions (RRm). Differences between $PaCO_2$ and $ETCO_2$ and

From Hotel-Dieu de France Hospital, School of Medicine, Saint Joseph University, Beirut, Lebanon.
* MD, Dept. of Anesthesia and Intensive Care.
** MD, Dept. of Cardiovascular and Thoracic Surgery.
*** MD, Dept. of Digestive Surgery.
Corresponding author: Dr Carine Zeeni, Hotel-Dieu de France University Hospital, Alfred Naccache street, P.O. Box: 166830, Tel: 961 1 615300, Fax: 961 1 615295, carinezeeni@hotmail.com.

between RRd and RRm were calculated for every simultaneous set of measurements.

Results: Bias, precision, limits of agreement (bias ± 2 precisions) between $PetCO_2$ and $PaCO_2$ were respectively as follows: 3.1, 1.4, 0.3 to 5.9 mmHg with a Pearson correlation coefficient of 0.6 and a P value of 0.001. As for RRd v/s RRm the values were: 2, 0.5, 1 to 3 breaths per minute and 0.8 with the same P value for the Pearson coefficient.

Conclusion: Limits of agreement between $PaCO_2$ and $ETCO_2$ pressure and between RRd and RRm are clinically acceptable. Nasal capnography is accurate for the monitoring of ventilation in extubated morbidly obese patients, following bariatric surgery.

Keywords: nasal capnography, morbid obesity, post-operative monitoring.

Introduction

Obesity is associated with significant decreased respiratory compliance, reduced functional residual capacity and ventilation-perfusion mismatching[1,2,3,4]. These impairments are exaggerated by anesthesia and surgery and increase the risk of post operative respiratory complications[5-12].

Several techniques may be used for continuous assessment of adequate oxygenation and ventilation in morbidly obese patients extubated following surgery. Pulse oxymetry is a reliable estimate of oxygenation, but detection of hypoventilation or airway obstruction, as evidenced by a decline in arterial oxygen saturation, can be delayed[13]. Electrical impedance respiratory rate monitoring is a well-established technique[14], but chest wall movement can occur with airway obstruction, which is interpreted by an impedance monitor as “breathing”[15]. Capnography through a nasal cannula provides an adequate monitoring of ventilation in extubated postoperative patients[16,17,18]. However, this monitoring technique may be affected by changes in dead-space, cardiac output and breathing patterns related to obesity[2,9]. Nasal capnography following surgery has not been evaluated in morbidly obese patients.

The aim of this study is to examine the accuracy of nasal capnography for the monitoring of ventilation in morbidly obese patients extubated following bariatric surgery.

Materials and Methods

Twenty-five consecutive adult patients, scheduled to undergo open bariatric surgery with a body mass index (BMI) > 40 kg/m², were enrolled in this prospective study. Exclusion criteria consisted of previous cardiac or pulmonary disease and sleep apnea syndrome. Dropout criteria included the need to maintain prolonged endotracheal intubation or mechanical ventilation postoperatively. The study was approved by our institutional Ethical Committee and informed written consent was obtained from the patients.

No premedication was given. General anesthesia was induced with 2.5 mg/kg of propofol and 1 µg/kg of fentanyl. Orotracheal intubation was facilitated by 1 mg/kg of succinylcholine. Patients were mechanically ventilated with 50% oxygen in nitrogen, a tidal volume of 10 ml/Kg of ideal body weight and a respiratory rate of 12 to 14 breath /min. A clinically adequate level of anesthesia and muscle relaxation was maintained with sevoflurane, fentanyl and cisatracurium. Heart rate, blood pressure, urine output, end-tidal CO_2, arterial oxygen saturation and rectal temperature were kept within normal limits. Patients underwent either gastric bypass or gastric restriction procedures through an upper abdominal incision.

At the end of surgery, any residual effect of muscle relaxant was reversed with neostigmine and atropine and all patients were extubated in the operating room. Postoperative analgesia was provided by 2 g of propacetamol and 0.1 mg/kg of morphine given 45 min before the end of surgery.

Once fully awake and breathing spontaneously, patients were transferred to the PACU and placed in a semi-sitting position. Monitoring included three leads ECG, invasive blood pressure measurement with a 20 gauge radial artery catheter and pulse oximetry.

A nasal cannula (Salter style, Arvin, USA) designed to administer oxygen (3 liters/min) and to sample expired carbon dioxide was appropriately positioned. The cannula was provided with a coaxial sampling catheter connected to a side stream infrared capnometer analyzer (Cardiocap/5, Datex-Ohmeda, Louisville, USA) calibrated with a 5% CO_2 gas container. Measurements were continuously displayed digitally as breath-to-breath end-tidal carbon dioxide partial pressure ($PetCO_2$) and respiratory rate (RR) and as an analog capnography waveform. An apnea alarm was triggered when expired carbon dioxide was not sensed by the capnometer for 20 seconds.

Measurements were recorded 10 minutes after a constant and normally shaped capnography waveform was obtained. Displayed $PetCO_2$ was noted and simultaneously an arterial blood sample was withdrawn from the radial artery catheter for the measurement of arterial carbon dioxide partial pressure ($PaCO_2$). Respiratory rate displayed by the capnometer was recorded and simultaneously measured by timed visual inspection of chest motion associated with breathing for one minute. One set of measurements was obtained for every patient. Episodes of apnea alarms were recorded and their causes elucidated. The study period was for one hour for every patient.

Categorical data were presented as raw values or percentages. Continuous data were presented as mean ± standard deviation. The correlation between $PetCO_2$ and $PaCO_2$ was evaluated by linear regression analysis and Pearson test**.** The agreement between $PetCO_2$ and $PaCO_2$ was assessed according to the Bland and Altman method: Bias was calculated as the mean difference between simultaneously measured $ETCO_2$ and $PaCO_2$; Precision was calculated as the standard deviation of the differences and limits of agreements were defined as the mean difference ± two standard deviations. The same statistical analysis was applied on simultaneously displayed and visually measured respiratory rates. All statistics were performed using the SPSS (version 8) statistical package.

Results

No patients met dropout criteria. Ten males and 15 females were studied. Their ages ranged from 25 to 45 years and their BMI ranged from 40 to 55 kg/m². Anesthesia duration was 180 ± 40 min.

The time to obtain a constant and normally shaped capnography waveform in the PACU, was between 1 and 4 minutes. During the one hour study period, a normal capnography waveform was observed between 54 and 59 minutes per patient.

Twenty five pairs of measurements were recorded. Bias, precision, limits of agreement and correlation coefficients between $PetCO_2$ and $PaCO_2$ and between displayed and measured RR are presented in Table 1.

Table 1

Bias, precision, limits of agreement and correlation coefficients between $PetCO_2$ and $PaCO_2$ and between displayed and measured respiratory rate.

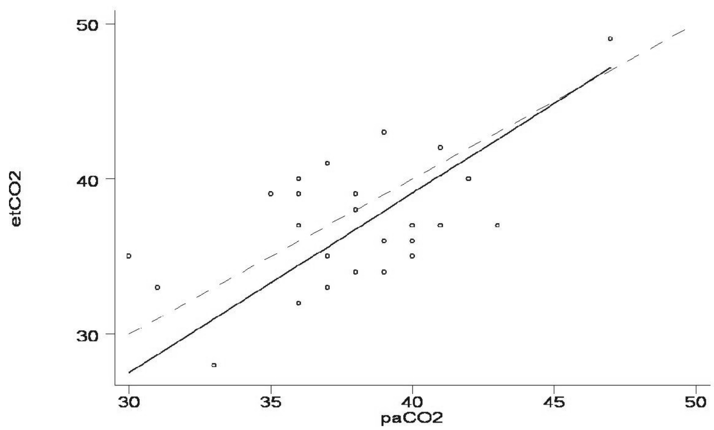
	Bias	Precision	Agreement	Pearson's r (*)	P Value for r
$PetCO_2$ vs. $PaCO_2$	3.1	1.4	0.3 - 5.9	0.6	0.001
Displayed vs. measured respiratory rate	2	0.5	1 - 3	0.8	0.001

$PetCO_2$ = end tidal CO_2 partial pressure. $PaCO_2$ = arterial CO_2 partial pressure.
r = Pearson's correlation coefficient.
For $PetCO_2$ vs. $PaCO_2$, bias precision and agreement are expressed in mmHg.
For displayed vs. measured respiratory rate, bias precision and agreement are expressed as number of breaths per minute.

The correlation between $PetCO_2$ and $PaCO_2$ is shown in Fig. 1.

Fig. 1

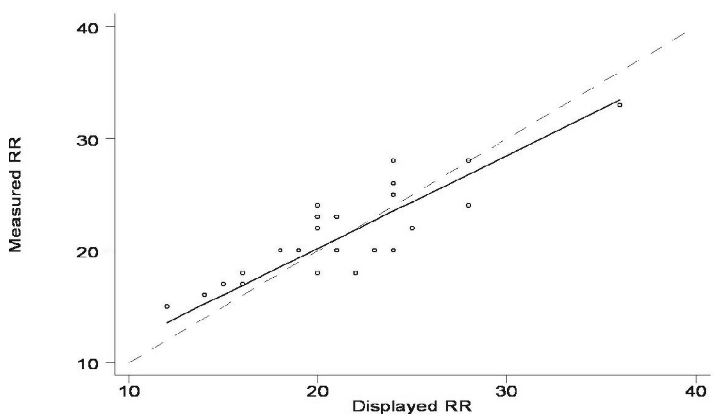
Correlation between $PetCO_2$ and $PaCO_2$. Some points, having the same coordinates, are overlapping and appear as one on the figure.



The correlation between displayed and measured RR is shown in Fig. 2.

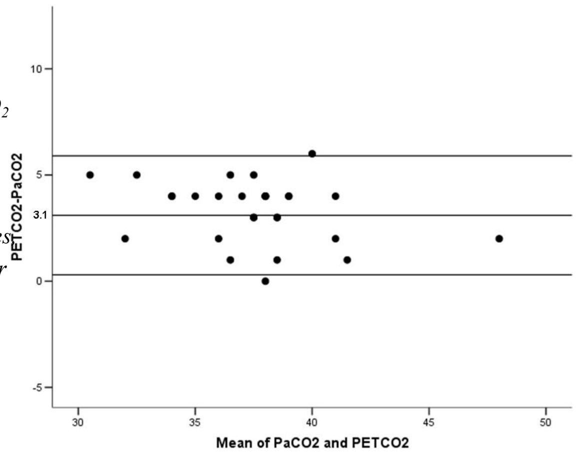
Fig. 2

Correlation between displayed and measured RR. Some points, having the same coordinates, are overlapping and appear as one on the figure.



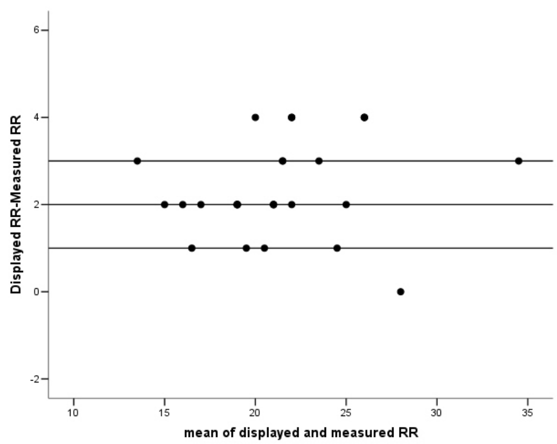
A plot of the difference between $PetCO_2$ and $PaCO_2$ against their mean value is presented in Fig 3.

Fig. 3
Plot of the difference between $PetCO_2$ and $PaCO_2$ against their mean value along with their limits of agreement. Some points, having the same coordinates, are overlapping and appear as one on the figure.



A plot of the difference between displayed and measured RR against their mean value is presented in Fig 4.

Fig. 4
Plot of the difference between displayed and measured RR against their mean value along with their limits of agreement. Some points, having the same coordinates, are overlapping and appear as one on the figure.



Limits of agreement between $PetCO_2$ and $PaCO_2$, as well as between displayed and measured RR are clinically acceptable for a wide range of measured values.

Fifteen episodes of apnea alarm were recorded in 10 patients. Five of these episodes were related to apnea or airway obstruction and the patients responded to verbal stimulation. The ten other episodes were false apnea alarm related to mouth breathing. No patient had an episode of apnea or airway obstruction detected clinically or by decline in arterial oxygen saturation and not sensed by the apnea alarm of the capnometer.

Discussion

This study is the first evaluation of the utility of nasal capnography in providing a real time graphic and digital assessment of ventilation in morbidly obese patients after bariatric surgery. Sampling and monitoring exhaled CO_2 by an intravenous catheter inserted through the plastic tubing of a nasal cannula has been reported several years ago[19]. Technical improvements have been added including the use on divided nasal cannula and micro stream capnometer[20,21,22]. Sampling errors can occur when the patient has oral ventilation or when exhaled CO_2 is diluted by a high oxygen flow rate[23].

In our study, patients had nasal breathing, the oxygen flow rate was limited to 3 liters/min and the nasal cannula was provided with a coaxial CO_2 sampling catheter. Normally shaped capnography waveform with adequate plateau indicated that obtained CO_2 samples were indeed end-tidal.

Several studies have described the use of non invasive capnography in extubated postoperative patients[16,17,18,24] and reported good correlation coefficients and acceptable limits of agreement between $PetCO_2$ and $PaCO_2$. However, all these studies have been performed in lean body weight patients with normal pulmonary function. We have evaluated nasal capnography in morbidly obese patients extubated after bariatric surgery. Morbid obesity reduces functional residual capacity and increases ventilation-perfusion mismatching[2,3,4,5]. Despite these changes, our results were similar to previous studies, indicating that nasal capnography provides a reasonable estimate of $PaCO_2$ in obese patients after surgery.

A number of studies have evaluated the use of non-invasive capnography to monitor respiratory rate and to detect apnea episodes in spontaneously breathing patients during the perioperative period[23,25,26,27]. These studies reported that, when compared with visual inspection or auscultation with a pretracheal stethoscope, capnography gave an accurate measurement of respiratory rate. Also, nasal capnography detected apnea episodes earlier than pulse oximetry or visual assessment. Similarly, in our study group of morbidly obese patients extubated after surgery, nasal capnography was reliable in monitoring respiratory and in detecting all apnea episodes. However, the percentage of false apnea alarm was not lower than commonly available methods for respiratory monitoring[26]**.** As obese patients are prone to postoperative upper airway obstruction[5], nasal capnography may be a good alternative to a time consuming continuous respiratory clinical assessment.

Our results have several limitations:

First, the observation time in this study was limited to one hour only. It would have been interesting to evaluate the accuracy and efficacy of nasal capnography during the first post-operative night during sedation or quiet sleep. The correlation between $PetCO_2$ and $PaCO_2$ may be poor in sedated patients and during changes in ventilatory conditions[28]. The P (a – ET) CO_2 gradient should be assessed in morbidly obese patients with abnormal breathing patterns.

Second, dead space (Vd/Vt) and venous admixture (Qs/Qt) were not calculated in this study. The P (a – ET) CO_2 gradient is directly affected by ventilation-perfusion mismatching. Liu et al found a close correlation between dead space, venous admixture and P (a – ET) CO_2 gradient in non-intubated surgical patients[24]. It would have been interesting to calculate Vd/Vt and Qs/Qt in our study population and to correlate these ratios with our measurements. However, such a study protocol required the systematic insertion of a pulmonary artery catheter and was not ethically acceptable.

Third, this study did not have the power to evaluate the effect of nasal capnography on clinically significant endpoints such as respiratory arrest or the need for ventilatory resuscitation. Large-scale controlled studies are needed to demonstrate that nasal capnography might reduce respiratory complications in morbidly obese patient extubated following bariatric surgery.

In conclusion, nasal capnography provided accurate monitoring of ventilation in morbidly obese patients extubated following bariatric surgery. This non-invasive and inexpensive technique may be used to complement both pulse oximetry and clinical assessment in this high-risk group of patients. Further randomized, controlled trials are needed to evaluate the clinical usefulness of nasal capnography after bariatric surgery.

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