Journal of Anesthesia & Clinical Research

Talley et al., J Anesth Clin Res 2012, 3:8
DOI: 10.4172/2155-6148.1000236

Research Article Open Access

EZ - PAP in the Postoperative Period: A Pilot Study

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Abstract

Induction of general anesthesia impairs gas exchange in the lungs, persists postoperatively, and may contribute to significant postoperative morbidity and health care cost. Laparoscopic surgery has been associated with an increased incidence of ventilatory complications. Multiple factors, including cardiac and respiratory comorbidities, surgical procedure and incision site, and body habitus contribute to these risks. The purpose of this study is to compare the effect of EZ PAP (a noninvasive positive airway pressure device) versus passive oxygen delivery via nasal cannula (conventional postoperative care) on postoperative ventilator status in patients scheduled to undergo laparoscopic surgery. A theoretical framework for ventilatory status with an emphasis on assessment of the patient with potential postoperative gas exchange impairment guided this study. Patients with body mass index (BMI) ≥ 35 having non-emergent laparoscopic abdominal surgery were recruited and randomly assigned to either the EZ PAP or the control group. Noninvasive pulse oximetry, capnography, oxygen liter flow, EZ PAP pressure, vital signs, and post operative opioids use were recorded at baseline, initiation of EZ PAP, 1 hour, 2 hours and 4 hours postoperatively. Demographic data was analyzed using descriptive statistics (e.g., means, standard deviations, and frequencies, percent) to characterize the sample. Repeated measures analyses of variance with multiple pre-planned comparisons of Least Square Means (LS) were performed to determine differences within groups. This study is relevant to practice in that findings may provide insight into who might most likely benefit from the use of EZ PAP; thereby, providing the basis for this targeted intervention to improve postoperative oxygenation, reduce carbon dioxide retention, enhancing overall quality of life and well-being in this population.

Keywords: EZ PAP; Continuous Positive Airway Pressure; Body mass index

Introduction

General anesthesia induces ventilation/perfusion (V/Q) mismatch in the immediate postoperative period. Such mismatches predispose patients to increased risk of perioperative complications; especially, obstructive sleep apnea (OSA). Many factors affect this risk; however, obesity is probably the leading risk factor for OSA in the anesthetized patient during the recovery phase of surgery. Morbidly obese patients are at an even greater risk from postoperative respiratory insufficiency. Several studies have shown an association between increased body habitus and the risk of OSA [1-3]. Obstructive Sleep Apnea occurs in approximately 40% of all obese individuals and about 70% of OSA patients are obese [4]. Residual effects of anesthesia can lead to OSA causing airway obstruction, hypoventilation, and atelectasis as well as blunt the ventilatory responses to both hypercarbia and hypoxemia [5].

Atelectasis causes deterioration of gas exchange during the perioperative period [6-8] and may lead to increased clinically relevant postoperative adverse outcomes. Induction of anesthesia is associated with radiographic evidence of increased atelectasis comprising an average of 15-20% of the lung volume in 87% of patients undergoing abdominal surgery [9]. Creation of pneumo peritoneum to an intra abdominal pressure of 11-13 mmHg has been radiographically shown to increase atelectatic lung volume by an average of 66% and decrease functional residual capacity by 16% compared to preoperative values in 100% of patients undergoing laparoscopic abdominal surgery [10]. Morbidly obese patient undergoing laparoscopic abdominal surgery have been shown to develop significantly greater amounts of atelectasis that their non-obese counterparts; and while non-obese patients' atelectasis resolves promptly in the postoperative period, morbidly obese patients' atelectasis persist for 24 hours or longer [11,12]. Clinically significant postoperative atelectasis and its associated decrease in functional residual capacity usually manifests as decreased arterial oxygen saturation [12]. Decreased arterial oxygen saturation is widely prevalent in the morbidly obese population with obstructive sleep apnea [13]. Due to redundant pharyngeal tissue, airway obstruction can occur in obese patients both during sleep and in the postoperative period. Positive End Expiratory Pressure (PEEP) is a widely available intervention that can be used to exert a positive pressure in the lungs at the end of exhalation to increase functional residual capacity (FRC); thus, preventing small airway collapse and reducing atelectasis. Continuous Positive Airway Pressure (CPAP) is currently well established as the most effective treatment for OSA [1,14]. CPAP is an effective treatment for persistent and refractory atelectasis, increasing arterial oxygenation and improving lung mechanics and V/Q match through alveolar recruitment [14-17], and may be used to treat postoperative atelectasis as well [5]. CPAP is useful postoperatively in patients with OSA or obesity as it accelerates reestablishment of preoperative pulmonary function, [18,19] and maintains a patent airway by creating a pneumatic splint of the nasopharyngeal airway [20] allowing for improved oxygenation and carbon dioxide (CO2) removal [21]. When used prophylactically, CPAP has been shown to decrease severe postoperative oxygenation disturbances in patients undergoing midline laparotomy for major vascular surgery [21]. CPAP has been shown to be safe in the postoperative period after abdominal surgery, even in cases of abdominal surgery involving bowel anastamosis [22].

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Received May 31, 2012; **Accepted** August 13, 2012; **Published** August 23, 2012

Citation: Talley HC, Twiss K, Wilkinson S, Buiocchi E, Lourens G, et al. (2012) EZ - PAP in the Postoperative Period: A Pilot Study. J Anesth Clin Res 3:236. doi:10.4172/2155-6148.1000236

Previous research does not provide adequate evidence that CPAP, delivered via a portable handheld device (EZ PAP), affects postoperative outcomes for morbidly obese patients receiving general anesthesia.

EZ PAP is an option for treating and preventing atelectasis when incentive spirometry won't maintain a patient's airway. The EZ PAP positive airway pressure system is an easily implemented, disposable device that delivers CPAP using flow from an oxygen flow meter via a mouthpiece or facemask that does not have a significant economic cost (Figure 2). EZ PAP provides a cost-effective and easily utilized form of CPAP that allows the patient to breathe normally through the mouthpiece or mask. The purpose of this study was to examine the respiratory effects, if any exist, of the use of EZ PAP and traditional oxygen delivery via nasal catheter in the immediate post-operative period in morbidly obese patients undergoing laparoscopic abdominal surgery and to identify the patient factors that correlate with these effects. Specifically, the following prediction was made for this study: the use of EZ PAP in this patient population will improve oxygenation, reduce carbon dioxide retention, and may reduce the risk of postoperative respiratory complications.

Materials and Methods

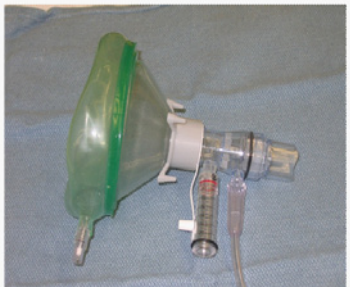
Participants

The study included 19 patients with American Society of Anesthesiologists (ASA) physical status classification system grade II or III, with a BMI equal to or greater than 35 kg/m^2, meeting the host facility criteria for OSA, and scheduled for non-emergent laparoscopic abdominal surgery. Exclusionary criteria included the following conditions: known cardiovascular diseases, chronic obstructive pulmonary disease, chronic hepatic or renal failure, diabetes mellitus, nasal obstruction that interacts with CPAP usage, and psychosis. This study was approved by the Michigan State University Institutional Review Board (IRB) and Sparrow Health System Institutional Research Review Committee (IRRC) and participants provided written informed consent prior to enrolling in the study.

Procedure

Eligible participants were provided information about the study in the preoperative holding area; patients meeting the inclusion criteria were consented, enrolled into the study then randomly assigned to one of two groups, EZ PAP or the control. After undergoing the scheduled surgical procedure with a standardized anesthetic, consisting of general endotracheal anesthesia with volatile inhalational agent, intravenous narcotic, neuromuscular blockade, and reversal of neuromuscular blockade, participants were transported to the PACU. Intraoperative narcotic was administered at the discretion of the anesthesia provider,

EZPAP® with manometer and face mask



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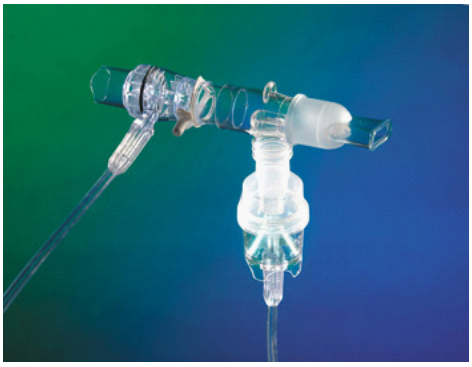

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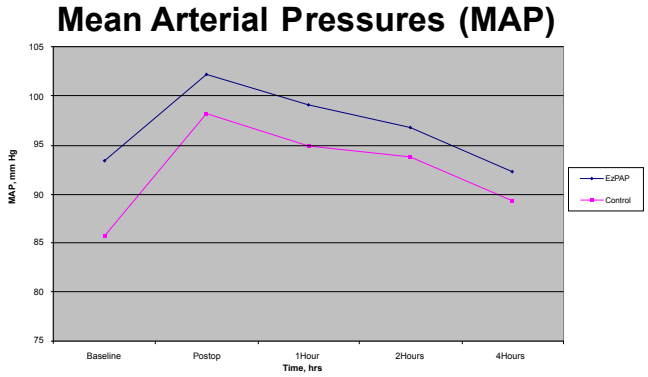
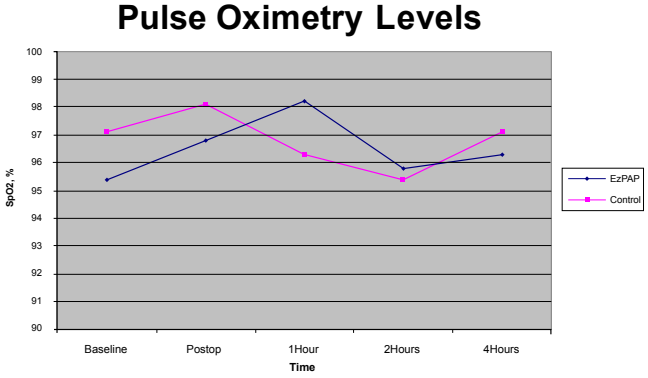


Figure 3:

and dosing was recorded using morphine equivalents for the purposes of this study. Baseline measurements of pulse oximetry, transcutaneous capnography, vital signs, and neck circumference were obtained from both groups. Upon arrival to the PACU, EZ PAP therapy was initiated in participants assigned to the experimental group, to maintain an airway pressure of 10-12 cm H_2O. EZ PAP therapy was continued for 60 minutes before converting to passive oxygenation via nasal cannula; participants in the control group received passive oxygenation via nasal cannula immediately following emergence from anesthesia. Intermittent measures of pulse oximetry, transcutaneous capnography, oxygen liter flow, EZ PAP pressure, vital signs, and post-operative narcotics were recorded up to 4 hours postoperatively or until discharge. The medical history, nursing records, anesthesia records, post anesthesia care unit records, information of EZ PAP usage, and medication administration records for the patients were reviewed and a data collection form for each patient was filled out by two trained graduate students.

During the preoperative interview and chart review, participants with a documented history of OSA were identified and questioned regarding home CPAP use. Participants without a diagnosis of OSA were assessed for OSA risk using a modified version of the facility's Obstructive Sleep Apnea Screen. This instrument is intended to stratify the likelihood of undiagnosed OSA by assessing and scoring the following risk factors: hypertension; snoring; daytime sleepiness; breath-holding, choking, or gasping during sleep; abnormal EKG, history of difficult airway, morning headache, and smoking history. Participants with a score of 6 or greater were identified as having a high likelihood of undiagnosed OSA for the purposes of data analysis.



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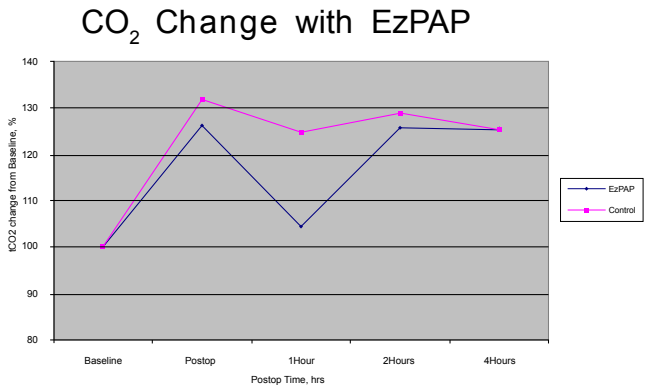

Figure 5:

EZ PAP therapy in the experimental group consisted of application of the EZ PAP device for one hour. The device delivers positive airway pressure by utilizing the Coanda effect to amplify air flow from a flowmeter to generate pressure. The EZ PAP device was connected to an oxygen flowmeter, and an airtight seal was created around the participant's nose and mouth, using a head strap and an oxygen mask. The goal of 10-12 cm H_2O pressure was achieved with an oxygen flow of 8-10 L/min. The airway pressure was verified using the EZ PAP manometer (Figure 1).

To measure the arterial partial pressure of CO_2, the Sentec transcutaneous capnography machine was used. This device provides a noninvasive measurement of CO_2 and has been shown to be within 1 mmHg of an invasive arterial carbon dioxide level, with overestimates and underestimates shown to be insignificant [23,24] (Figure 3).

Data analyses

Data were analyzed using the SAS software package (SAS; Cary, NC). The primary analysis performed was done using univariate descriptive and correlational statistics from the questionnaire and various demographics (age, gender, BMI). Statistical significance was defined as $p>0.05$ using two tailed tests.

Results

Nineteen participants scheduled for non-emergent laparoscopic surgery were included in the study. This sample was composed of all Caucasian women, and the mean age of participants was 47.7 ± 9.9 for the EZ PAP and 42.9 ± 13.1 for control. The BMI averaged 46.8 ± 10.1 and 42.4 ± 3.7 for EZ PAP and control respectively. There were no significant differences in OSA Risk Factor Score, ASA Physical Status, and Neck Circumference for the sample. Table 1 shows the descriptive statistics of the scores on the demographic data for the sample.

Discussion

General anesthesia regularly impairs pulmonary gas exchange and respiratory mechanics in the morbidly obese anesthetized patient. Strategies to improve pulmonary function in the obese patient postoperatively would decrease atelectasis, a major contributor to complications in this population. The goal of this study was to examine the respiratory effects, if any exist, of the use of EZ PAP in the immediate post-operative period on morbidly obese patients undergoing laparoscopic abdominal surgery and to identify the patient factors that correlate with these effects. We predicted that the use of EZ PAP in our patient sample will improve oxygenation and reduce carbon dioxide retention.

Joris et al. reported that instituting NIV PAP (noninvasive positive airway pressure) devices in healthy obese patients prophylactically in the post-operative period improves spirometric lung function (FVC and FEV1 (forced vital capacity and forced expiratory volume in one second)) and oxygenation (PaO_2 and SpO_2 (partial pressure of arterial oxygen and saturation of pulse oximetry)) [25-27] (Figure 4). All participants had an increase in CO_2 postoperatively. We also found that the EZ PAP group had increased SpO_2 levels postoperatively compared to control and lower CO_2 levels 1 hour after cessation of general anesthesia and increased SpO_2 levels compared to control.

Patients who wear NIV PAP devices for 12-24 hours in the immediate post-operative period have significantly less postoperative spirometric pulmonary dysfunction and return to baseline pulmonary function at an accelerated rate, indicating that the effects of NIV PAP continue even after the PAP (positive airway pressure) therapy has been discontinued [25,27]. Applying CPAP (continuous positive airway pressure) in the OR immediately following tracheal extubation is more effective than delaying PAP therapy until 30 minutes after extubation in improving immediate postoperative spirometric lung function and maintaining improved function at 24 hours [28].

There are some limitations with regard to method and data collection. Limitations in this study include a small sample size, a lack of gender diversity, and most of the participants were relatively healthy. The incidence of OSA among obese patients is a common, chronic and complex disease that causes economic and social costs to both the patient and the public. In this study, these costs were not directly addressed. In an effort to collect an adequate sample size, patients did differ on a number of variables that may impact the findings. In conclusion, our findings demonstrate a consistent relationship between EZ PAP and SpO_2 levels postoperatively but there was significant variability in this relationship. Patients in the EZ PAP group demonstrated improvement in ventilatory effort in the first few hours (Figure 5); however, there

Characteristic	EzPAP (M ± SD)	Control (M ± SD)
Age (yrs)	47.7 ± 9.9	42.9 ± 13.1
BMI (kg/m^2)	46.8 ± 10.1	42.4 ± 3.7
OSA Risk Factor Score	1.8 ± 1.1	3.2 ± 1.2
ASA Physical Status	2.6 ± 0.5	2.4 ± 0.5
Neck Circumference (cm)	45.0 ± 4.2	40.8 ± 1.9

Demographic characteristics of sample

Table 1:

was no correlation between OSA risk factor score, neck circumference, BMI and postoperative CO_2 levels and SpO_2 levels in either group at 4 hours. These results suggest that morbidly obese patients may benefit from EZ PAP intervention to improve their ventilatory status up to 4 hours postoperatively; however, interventions must be aimed at improving these patient's status for longer periods. This information could potentially provide insight into who might most likely benefit from the use of EZ PAP; thereby, providing the basis for this targeted intervention to improve postoperative oxygenation, reduce carbon dioxide retention, enhancing overall quality of life and well-being in this population.

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