

Automated Notification of Suspected Obstructive Sleep Apnea Patients to the Perioperative Respiratory Therapist: A Pilot Study

Satya Krishna Ramachandran MD FRCA, Sachin Kheterpal MD MBA,
Carl F Haas MLS RRT FAARC, Kelly A Saran MSc RN, and Kevin K Tremper MD FRCA

BACKGROUND: Obstructive sleep apnea (OSA) increases the risk of central and obstructive apneas after anesthesia, but the vast majority of patients with OSA are undiagnosed preoperatively. Current guidelines promote the use of postoperative continuous positive airway pressure (CPAP) in patients with OSA. Owing to the complex postoperative requirements of these patients, respiratory therapists (RTs) could substantially improve these patients' clinical management in the immediate postoperative period. We describe a system that identifies patients with suspected or documented OSA and automatically alerts the perioperative RT. **METHODS:** Patients who presented for surgery were preoperatively assessed, and if the patient had a diagnosis of OSA or OSA risk factors, the perioperative RT automatically received a paging alert, after the surgery. The RT reviewed the patient postoperatively and instituted CPAP or bi-level positive airway pressure (BiPAP), as indicated. We collected data on triggers for the automated alerts and utilization of CPAP and BiPAP. We reviewed risk-management data to analyze the effect of this intervention on postsurgical sudden-onset acute respiratory compromise. **RESULTS:** Of 7,422 patients who presented for surgery over a 5-month period, 766 had an OSA diagnosis or OSA risk factors. There were an average of 7–8 alerts per work day (range 2–18 alerts per day). On average, 2 patients per day were treated with CPAP/BiPAP in the post-anesthesia care unit or the postoperative general ward as a result of the alerts. The median paging alert time was 10:30 AM. There were no episodes of sudden-onset postoperative acute respiratory compromise after institution of the OSA alert system. **CONCLUSIONS:** As part of a hospital-wide postoperative policy, our automated OSA alert and perioperative RT system helped prevent sudden-onset acute respiratory compromise in postoperative patients with OSA or at risk of OSA. *Key words:* obstructive sleep apnea; continuous positive airway pressure; postoperative; respiratory therapist; automated paging alert; post-anesthesia care unit. [Respir Care 2010;55(4):414–418. © 2010 Daedalus Enterprises]

Introduction

Obstructive sleep apnea (OSA) is a prevalent condition in patients presenting for surgery. It is estimated that up to 24% of middle-aged males and 9% of middle-aged females may have OSA, over 80% of whom are undiag-

nosed.¹ Few patients undergo preoperative polysomnography or have OSA treatment plans such as continuous positive airway pressure (CPAP), bi-level positive airway pressure (BiPAP), surgery for OSA, or tracheotomy. Though the impact of OSA on perioperative morbidity has been explored previously,^{2,3} few data are available on the practical aspects of postoperative management of these patients. Several robust screening tests have been developed to screen for high risk of OSA, but none specifically predict the risk of postoperative respiratory insufficiency.⁴ On the other hand, OSA is a complex condition that often coexists with morbid obesity⁵ and chronic obstructive pulmonary disease.⁶ Therefore, these patients typically have a high requirement for postoperative multidisciplinary care, involving respiratory care and acute pain management.

Satya Krishna Ramachandran MD FRCA, Sachin Kheterpal MD MBA, and Kevin K Tremper MD FRCA are affiliated with the Department of Anesthesiology; Carl F Haas MLS RRT FAARC is affiliated with Critical Care Support Services; and Kelly A Saran MSc RN is affiliated with the Department of Risk Management, University Hospital, University of Michigan, Ann Arbor, Michigan.

The authors have disclosed no conflicts of interest.

Though there is little doubt of the benefit of CPAP/BiPAP in minimizing the long-term complications of OSA, there is no consensus in the literature on CPAP/BiPAP for postoperative patients with OSA. However, there are a few important considerations surrounding postoperative CPAP/BiPAP.

The first 24 hours after surgery are a high-risk period for adverse respiratory events related to opioids and residual anesthesia.⁷ Recent literature points to a substantial increase in central and obstructive apneas in postoperative patients with high risk of OSA.⁸ The final common pathway for postoperative apneas or atelectasis is hypoxemia. Squadrone and others demonstrated the significant benefits of early CPAP in patients with postoperative hypoxemia, including reduced postoperative pulmonary complications, pneumonia, sepsis, and death.^{9,10} The practice guidelines of the American Society of Anesthesiologists¹¹ and American College of Physicians⁹ promote the use of postoperative CPAP. Therefore, the primary purpose of this study was not to study the efficacy of CPAP on postoperative respiratory morbidity. Instead, the present study addresses the distinct lack of data concerning the hospital-wide processes involved in the clinical application of those valuable clinical principles. We describe the creation and performance of a collaborative safety process to minimize postoperative risk from OSA in a high-OSA-risk population.

One of the most feared complications of OSA, both in the community and in the hospital, is sudden death.¹² Following an unanticipated sentinel death of a postoperative patient from sudden-onset acute respiratory compromise, our institution adopted a multi-modal and multidisciplinary approach that centers on early identification and enhanced monitoring of high-risk patients undergoing surgery. The components of this new safety policy include preoperative screening for OSA, consideration of early postoperative CPAP, and mandatory overnight pulse oximetry for patients on parenteral opioids. As part of this safety initiative, we explored the feasibility of having a perioperative respiratory therapist (RT) whose role and impact on patient care would complement the efforts of the anesthesiologists and the post-anesthesia-care-unit nurses. We developed an automated page alert system, in conjunction with the electronic anesthesia record, to facilitate this clinical collaboration. This report describes the role of the perioperative RT and our innovative paging system to alert RTs of patients at high risk of OSA.

Table 1. Primary Trigger Criteria for Automated Alert

Trigger Criteria	<i>n</i>	%*
Uses CPAP/ BiPAP at home	248	32
Tested positive for OSA	150	20
Snores loud enough to wake others	164	21
Prescribed CPAP/BIPAP but not using it	112	15
Diagnosed with sleep study but OSA is untreated	68	9
Daytime sleepiness	35	5

* Percent of alerts from this trigger. False alarms were noted in up to 5.7% of instances, when non-specific user entry into the data form generated an alert when there was no specific need for reviewing that patient. Some patients had more than one trigger criterion, so the percent values do not sum to 100, and the number of triggers is more than the number of patients.

CPAP = continuous positive airway pressure

BiPAP = bi-level positive airway pressure

OSA = obstructive sleep apnea

Methods

We designed a prospective observational study that included all adult patients who presented for surgery to the University Hospital, Ann Arbor, Michigan. The requirement for informed consent was waived by the institutional review board because no clinical interventions were studied and no patient-identifiable data were used. The exclusion criteria were: < 18 years old, and incomplete documentation of clinical evaluation. In the preoperative period, the patients were reviewed by anesthesiology clinicians as part of their preoperative assessment. We collected preoperative, intraoperative, and postoperative data from routine clinical documentation entered by anesthesiology residents, attending staff, and a certified registered nurse anesthetist into the institution's perioperative clinical information system. Although the data analysis was retrospective, this documentation, which included a structured electronic preoperative clinical evaluation, was performed prospectively on every patient.

The anesthesia information system (Centricity, General Electric Healthcare, Waukesha, Wisconsin) is a comprehensive perioperative information system that includes all documentation associated with anesthesia and perianesthesia nursing care. In the respiratory section of the electronic anesthesia preoperative assessment form we developed a set of questions to identify patients with OSA or at high risk of OSA (Table 1) and to document OSA treatment plans, including CPAP, BiPAP, and surgery for OSA. This preoperative form provided clinical documentation and collected data for observational research studies. The form is structured as a pick-list in which the clinician chooses items from a list, and can also enter text if necessary.

Respiratory Therapist Alert

In June 2007, our department implemented an automatic paging notification, via the anesthesia information system,

Correspondence: Satya Krishna Ramachandran MD FRCA, Department of Anesthesiology, University Hospital, 1 H427, University of Michigan, Box 0048, 1500 E Medical Center Drive, Ann Arbor MI 48109-004. E-mail: rsatyak@med.umich.edu.

to the perioperative RT assigned to the post-anesthesia care unit. If any of the pick-list OSA elements were selected during the routine preoperative anesthesia assessment, this triggered an automatic page alert to the perioperative RT. The alert included the patient's name, hospital number, and assigned bed space.

Initially, the system was set to send the alert before the surgery and to have the RT assess the patient in the preoperative area (we called this the preoperative model). The RT assessed the patient preoperatively, identified and labeled any CPAP/BiPAP device(s) brought in by the patient, checked the device(s), and transferred the devices to the post-anesthesia care unit in preparation for the patient's stay in the post-anesthesia care unit. Table 2 summarizes the perioperative RT's general functions.

Subsequently, we changed the alert system to generate the alert when a post-anesthesia-care-unit bed was assigned (we called this the postoperative model) (Fig. 1). In the postoperative model, the preoperative area nurses labeled and transferred the patient's CPAP/BiPAP device(s) to the post-anesthesia care unit, where the RT prepared the devices at the bedside, in time for the patient's arrival to the post-anesthesia care unit. When the patient arrived, the team (which included the perioperative RT and a faculty anesthesiologist) used a consensus approach to assess the patient's need for mechanical ventilation, CPAP, BiPAP, and/or oxygen.

From the anesthesia and respiratory care records we recorded the perioperative-RT-alert triggers and the need

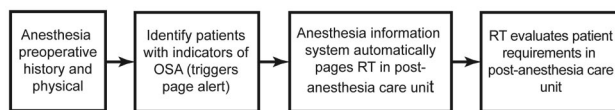


Fig. 1. Automated process to alert the perioperative respiratory therapist (RT) to a patient with a diagnosis of or at risk for obstructive sleep apnea.

for postoperative CPAP/BiPAP. These data were collected and analyzed in spreadsheet software (Excel, Microsoft, Redmond, Washington).

Finally, we reviewed the hospital risk-management database for reports of postoperative sudden-onset acute respiratory compromise (with or without death) in our institution, to compare its occurrence before and after the implementation of the perioperative RT and opioid safety guideline.

Results

Between June 1 and October 31, 2007, 7,422 surgeries were performed and recorded in the electronic record. Our query of the anesthesia information system identified 821 page alerts to the RT in the post-anesthesia care unit; however, some of those alerts were duplicates and we removed those from the sample. A total of 766 patients (10% of all surgical cases) had a documented history of OSA or suspected OSA. Any combination of OSA criteria entered by the anesthesiologist into the preoperative assessment form triggered an alert to the perioperative RT (see Table 1).

The median paging alert time was 10:30 AM. The time spread of alerts was 07:30 AM to 11:00 PM, which represents the spread of post-anesthesia-care-unit bed requests during the day and night. Staffing for respiratory care was provided on-site from 7:00 AM to 7:00 PM, and RTs were readily available from off-site, to provide respiratory services between 7:00 PM and 11:00 PM.

CPAP/BiPAP was postoperatively applied, either in the post-anesthesia care unit or on the general ward, to 228 patients (30% of 766); 177 (78% of 228) of those patients used CPAP/BiPAP at home, 147 (64% of 228) of whom brought their own equipment to the hospital. Thus, an average of 7.4 automated alerts were generated to the perioperative RT per working day, from 6.9 patients day, resulting in 2–18 discrete patient contacts per day. On average, 2 patients per day were treated with CPAP/BiPAP in the post-anesthesia care unit or the postoperative general ward. Noninvasive ventilation was instituted in 51 patients who did not have a preoperative sleep study, and 30 patients who did not bring their CPAP/BiPAP equipment from home. Thus, hospital CPAP/BiPAP devices were used with 81 patients during the study period. There was

Table 2. General Functions of the Perioperative Respiratory Therapist

Review the OSA Diagnosis of Postoperative Patients in the Post-Anesthesia Care Unit
Use of home CPAP
Home CPAP settings
Evaluate home CPAP machine
Indications for Institution of CPAP/BiPAP in Patients With Known OSA
Substantial postoperative desaturation or recurrent desaturation
Observed apneas
Institution and Titration of CPAP/BiPAP in Patients Without Known OSA
In conjunction with physician and anesthesiologist
Substantial postoperative desaturations and/or observed apneas
Facilitate ICU admission based on need for postoperative CPAP/BiPAP
Evaluate and Treat Patients With Postoperative Desaturation in the Post-Anesthesia Care Unit
Treat with incentive spirometry and bronchodilator
Optimize postoperative oxygen therapy
Evaluate and Manage Patients Who Need Postoperative Mechanical Ventilation
Ensure Continuity of Respiratory Therapy into the Postoperative Period, Beyond the Post-anesthesia Care Unit Stay

no written protocol for instituting CPAP/BiPAP, but local practice standards were applied in all patients, including identifying the patient's home CPAP/BiPAP settings and initiating CPAP/BiPAP based on those settings. If the patient did not show adequate response in S_{pO_2} or arterial blood gas values within a clinically acceptable time frame, a decision was made either to increase noninvasive support or to institute invasive ventilation. For this reason, patients who did not have a previous CPAP titration based on a sleep study were treated as ICU patients if they demonstrated clinically important postoperative desaturation and/or apneas. These patients underwent overnight pulse oximetry and CPAP/BiPAP strictly in the ICU.

We abandoned the preoperative model after a couple of months, for 2 reasons. First, not all patients had a complete anesthesia workup prior to presentation to the preoperative area, and with those patients the automated alert could not be triggered in time for the RT to review the patient. Second, it became difficult to ensure that all patients were seen by the RT at the start of the day, especially when several patients with OSA presented for 07:30 AM start. The postoperative model ensured that the RT was able to organize his or her day schedule more efficiently and review each individual patient's details before their arrival in the post-anesthesia care unit.

We reviewed the hospital's risk-management database for cases of postoperative sudden-onset acute respiratory compromise, alone or leading to cardiac arrest. These included unresponsive patients with severe hypoventilation that required naloxone, and patients who were suddenly found unresponsive with or without pulseless rhythms. Thirty-six patients were identified in the 5.5-year period between 2001 and June 2007 (mean 5.5 patients per year). Thirty-one of those patients survived the event to discharge, but 5 patients died due to complications of the acute respiratory compromise. We found no cases of sudden-onset postoperative acute respiratory compromise in the database following June 2007.

Discussion

We have described the scope of work for a perioperative RT and the innovative use of automated paging alerts to facilitate early postoperative assessment and respiratory care management of patients with OSA. The ready availability of trained RTs improves the seamless transition from invasive to noninvasive ventilation in postoperative patients. Although the majority of patients who were managed with CPAP/BiPAP in this observational study were previously diagnosed with OSA, our data suggest a definite need for postoperative noninvasive ventilation in some patients with features suggestive of OSA without a confirmatory diagnosis. This study was observational in nature and not designed to look specifically for outcome

benefit; however, no episodes of postoperative acute respiratory compromise were identified in these high-risk patients following institution of the perioperative RT system.

Despite practice guidelines from both the American Society of Anesthesiologists and the American College of Physicians, the immediate postoperative period presents challenges for respiratory care, especially in the context of OSA that requires CPAP/BiPAP. On the other hand, the post-anesthesia care unit represents the transition of care from one-on-one monitoring to lower levels of monitoring on the floors. Thus, the most powerful interventions to increase patient safety and decrease complications may transpire during patient stay in the post-anesthesia care unit, which makes interdisciplinary communication especially prudent during that time. However, sharing the information about patients either diagnosed with or suspected of OSA is often challenging, leaving potential gaps in the hand-offs between the operating room, post-anesthesia care unit, and receiving patient care unit. The addition of an RT to the post-anesthesia care unit staff and the implementation of the automatic OSA alert system allow clinicians to identify at-risk patients earlier, initiate CPAP/BiPAP, and promote early decision making to admit these patients to units with higher levels of monitoring and lower nurse/patient ratios. Our perioperative RT system has improved communication between the post-anesthesia care unit and the in-patient units regarding these patients' respiratory needs.

An important aspect of this study is the innovative use of automated alerts based on the anesthesia information system. We have previously shown how the same methods can be used to improve billing for anesthesia procedures.¹³ In the current study the automated alerts provided the RT real-time patient-specific information that allowed preparedness for timely respiratory care. However, the benefits of the perioperative RT system must be balanced with the costs of providing such care. The need for up to 18 respiratory interventions per day in this report permits the allocation of dedicated personnel to the post-anesthesia care unit in a busy university hospital. Other post-anesthesia care units should evaluate their requirement for a perioperative RT, based on local availability of RTs and daily case-load.

Another interesting finding of this study involves the use of postoperative CPAP/BiPAP in patients who did not have a preoperative explicit diagnosis of OSA. In other words, those patients were treated with CPAP/BiPAP for either postoperative respiratory insufficiency or postoperative apneas. We believe that the presence of an RT in the post-anesthesia care unit helped bring forward this decision, especially as there was a continuity of care extending from the post-anesthesia care unit to the postoperative floor. Recent data demonstrate the substantial benefit of CPAP

in patients who develop postoperative hypoxemia.^{10,14} Bringing forward the decision to use CPAP/BiPAP in these patients may hasten recovery by improving ventilation and pulmonary excretion of anesthetic gases. Further work needs to be done to identify which patients will benefit from elective postoperative CPAP/BiPAP.

Limitations

First, the study was not powered to identify a difference in postoperative outcomes. Several reports have found that early CPAP/BiPAP is associated with significant improvements in postoperative oxygenation, pulmonary complications, and mortality.^{9,10,14} Our purpose was to develop and explore a robust system of perioperative respiratory care for patients at highest risk of postoperative respiratory compromise.

Second, we did not prospectively seek or collect data on patient adherence for CPAP. In line with existing post-anesthesia-care-unit policies, postoperative CPAP is not offered to patients who are deeply sedated after surgery, and lack of adherence to CPAP is managed with a clinical decision process for endotracheal intubation and positive-pressure ventilation, both of which involve the RT.

Finally, the reporting of acute respiratory compromise, although supported by a highly proactive risk-management structure, is essentially dependent on individual clinicians, so we have refrained from presenting incidence statistics, due to the risk of under-reporting. Despite this drawback, there was a clear absence of postoperative sudden-onset acute respiratory compromise following implementation of the perioperative RT system and the hospital-wide opioid policy. There could be several reasons for this. Early identification of higher-risk patients via the paging alert system could have improved the speed of response to changes in patient physiology, as monitored via pulse oximetry and more robust nurse monitoring. The hospital-wide approach to the problem could have directly increased awareness of postoperative acute respiratory compromise and thereby improved responses to clinical needs. Increased utilization of postoperative lung-recruitment maneuvers, CPAP/BiPAP, and positive-pressure ventilation, implemented by RTs, reflects a proactive approach to the substantial risks associated with general anesthesia in this high-risk population. The finding of improved outcomes is unlikely to be related to one aspect of the change in management, but, rather, it reflects the success of a multimodal and multidisciplinary approach to the complex clinical requirements of high-risk patients.

Conclusions

We have demonstrated a model for automated alert of a perioperative RT in a busy university hospital post-

anesthesia care unit. In line with the recommendations of the American Society of Anesthesiologists and the American College of Physicians, this innovation improves patient safety and continuity of care for patients at high risk of postoperative acute respiratory compromise, and describes a process for their perioperative respiratory care.

REFERENCES

1. Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep-disordered breathing among middle-aged adults. *N Engl J Med* 1993;328(17):1230-1235.
2. Gupta RM, Parvizi J, Hanssen AD, Gay PC. Postoperative complications in patients with obstructive sleep apnea syndrome undergoing hip or knee replacement: a case-control study. *Mayo Clin Proc* 2001;76(9):897-905.
3. Hwang D, Shakir N, Limann B, Sison C, Kalra S, Shulman L, et al. Association of sleep-disordered breathing with postoperative complications. *Chest* 2008;133(5):1128-1134.
4. Ramachandran SK, Josephs LA. A meta-analysis of clinical screening tests for obstructive sleep apnea. *Anesthesiology* 2009;110(4):928-939.
5. Dixon JB, Schachter LM, O'Brien PE. Predicting sleep apnea and excessive day sleepiness in the severely obese: indicators for polysomnography. *Chest* 2003;123(4):1134-1141.
6. Hiestand D, Phillips B. The overlap syndrome: chronic obstructive pulmonary disease and obstructive sleep apnea. *Crit Care Clin* 2008;24(3):551-563.
7. Taylor S, Kirton OC, Staff I, Kozol RA. Postoperative day one: a high risk period for respiratory events. *Am J Surg* 2005;190(5):752-756.
8. Blake DW, Chia PH, Donnan G, Williams DL. Preoperative assessment for obstructive sleep apnoea and the prediction of postoperative respiratory obstruction and hypoxaemia. *Anaesth Intensive Care* 2008;36(3):379-384.
9. Lawrence VA, Cornell JE, Smetana GW. Strategies to reduce postoperative pulmonary complications after noncardiothoracic surgery: systematic review for the American College of Physicians. *Ann Intern Med* 2006;144(8):596-608.
10. Squadrone V, Coia M, Cerutti E, Schellino MM, Biolino P, Occella P, et al. Continuous positive airway pressure for treatment of postoperative hypoxemia: a randomized controlled trial. *JAMA* 2005;293(5):589-595.
11. Gross JB, Bachenberg KL, Benumof JL, Caplan RA, Connis RT, Cote CJ, et al. Practice guidelines for the perioperative management of patients with obstructive sleep apnea: a report by the American Society of Anesthesiologists Task Force on Perioperative Management of patients with obstructive sleep apnea. *Anesthesiology* 2006;104(5):1081-1093; quiz 1117-1088.
12. Gami AS, Howard DE, Olson EJ, Somers VK. Day-night pattern of sudden death in obstructive sleep apnea. *N Engl J Med* 2005;352(12):1206-1214.
13. Khetarpal S, Gupta R, Blum JM, Tremper KK, O'Reilly M, Kazanjian PE. Electronic reminders improve procedure documentation compliance and professional fee reimbursement. *Anesth Analg* 2007;104(3):592-597.
14. Ferreyra GP, Baussano I, Squadrone V, Richiardi L, Marchiaro G, Del Sorbo L, et al. Continuous positive airway pressure for treatment of respiratory complications after abdominal surgery: a systematic review and meta-analysis. *Ann Surg* 2008;247(4):617-626.