

# Sleep and Sleep-Disordered Breathing in the Hospitalized Patient

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Clinicians are becoming more aware of the risks of sleep deprivation and unrecognized sleep-disordered breathing in hospitalized patients, most importantly in those patients planning to undergo surgical procedures. Polysomnography is difficult to perform in the hospital setting, such that actigraphy or urinary metabolites of melatonin are often used as surrogate measures, and show that sleep is markedly impaired. Patients in the medical intensive care unit with sepsis or requiring mechanical ventilation may show complete absence of the normal circadian rhythm pattern, and many centers have initiated sleep-enhancement protocols. In postoperative patients, rapid-eye-movement sleep is nearly obliterated, especially in the first 1–2 days after surgery, and this appears closely related to the use of high-dose opioids. Sleep-disordered breathing is common in postoperative patients, and tools such as the Sleep Apnea Clinical Score or the STOP-BANG (Snoring, Tiredness, Observed apnea, and high blood Pressure - Body mass index, Age, Neck circumference, and Gender) questionnaires have been utilized to predict the possibility of obstructive sleep apnea (OSA) and postoperative respiratory complications. Protocols to evaluate patients that determine the need and process for positive-airway-pressure treatment in the hospital patient with OSA are being developed. An obstructive apnea systematic intervention strategy protocol to deal with patients with suspected OSA can help guide diagnostic and therapeutic decision making. Hospitals

**that are proactive in the development of protocols for identification and management of patients with sleep-disordered breathing are likely to be rewarded with reduced complications and costs, and the issue is sure to be incorporated in future pay-for-performance evaluations.** *Key words:* obstructive sleep apnea; OSA; sleep-disordered breathing; sleep in the hospital; sleep with mechanical ventilation; sleep apnea questionnaires. [Respir Care 2010;55(9):1240–1251. © 2010 Daedalus Enterprises]

## Introduction

There is a rising tide of concern regarding the risks of sleep deprivation and unrecognized sleep-disordered breathing in hospitalized patients, especially in those with obstructive sleep apnea (OSA) planning to undergo surgical procedures. The possible consequences may include neurologic, respiratory, or cardiac complications, prolonged hospital or intensive care unit (ICU) stay, and even increased mortality. Clinicians have been urged to find better ways to identify potential problems before they occur and then have appropriate monitoring and treatment plans to deal with issues as they present. Anesthesiologists and others have begun to produce guidelines and encourage development of local protocols to attend to these matters. The objectives of what follows include initially a presentation of information about what is known regarding sleep disruption and sleep-disordered breathing as it exists in hospitalized patients. Some special mention will be made of patients with specific primary medical diagnoses (cardiovascular diseases and sepsis) and surgical conditions (abdominal, cardiac, and orthopedic). The unique obstacles facing patients in the ICU, and especially those undergoing mechanical ventilation, will be reviewed. Most importantly, I will review the apprehension surrounding OSA in the perioperative situation and various evolving protocols that have been explored and that will need to be refined in the future in order to protect patients in the hospital environment.

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## Sleep and Consequences of Sleep Disruption in the Hospital

### Acute Sleep Loss and the Hospital Patient

It is intuitively understood that sleep is essential for normal human function, and there is sufficient scientific evidence to support the fact that sleep loss leads to unhealthy events.<sup>1</sup> When sleep is restricted, for whatever reason, a host of undesirable neuro-behavioral and physiologic results may occur. Sleep restriction can be acute or cumulative and chronic; it can be complete or partial with respect to total sleep time, sleep stage, or degree of fragmentation. The determination of which type might occur is related to the environment and conditions of the situation.<sup>2</sup> Certainly in the hospital patient, all types of sleep restriction can occur. Experimental and epidemiologic studies of sleep-deprived healthy subjects reveal adverse effects on metabolic and endocrine functions,<sup>3</sup> immune responses,<sup>4</sup> and cardiovascular effects,<sup>5</sup> indicating that sleep loss may substantially contribute to undesirable consequences. It is not difficult to imagine that an individual who has already become ill and requires hospitalization should be more vulnerable to medical problems when sleep is denied or further compromised by sleep-disordered breathing, as outlined in Figure 1.

Sleep disruption and insomnia have long been known to affect hospitalized patients, caused by the acute effects of illness, environmental sleep disruption, medication, anxiety, pain, depression, and the especially challenging problem of delirium in the elderly.<sup>6</sup> The nursing literature has been very attentive to this problem, noting that the causes can be categorized into 3 main groups, including environmental, physiological, and psychological, all of which have a variety of interventions that can be done to promote better sleep.<sup>7</sup> The interest in hospital sleep difficulties is worldwide, including Asia, and in one study from Pakistan, additional disturbing items identified in high percentages included other patient noises such as snoring, cell telephone use, and annoyances of supplemental oxygen equipment.<sup>8,9</sup> Protocols have been developed to identify patients' sleep patterns and problems in order to promote adoption of beneficial protocols to enhance sleep, with particular attention to noise reduction and timing of testing.<sup>10,11</sup>

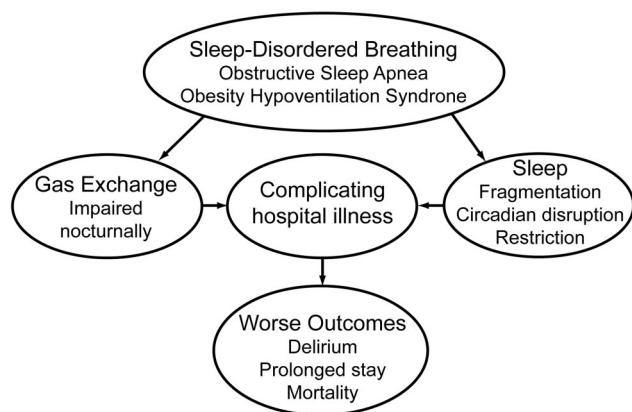


Fig. 1. Effect of sleep-disordered breathing on the hospitalized patient.

### Measuring Sleep in the Hospital

Polysomnography (PSG) is already complicated enough when performed in a controlled laboratory environment, so it is not surprising that limited studies have described actual PSG results in the hospital. Nevertheless, this has been undertaken even in the ICU, and one study did 48 hours of continuous PSG on 10 patients in a respiratory ICU.<sup>12</sup> Patients, not surprisingly, showed marked reduction in total sleep time, slow-wave and rapid-eye-movement (REM) sleep stages, and a marked increase in wakefulness and stage 1 sleep. When assessing the disturbances to sleep, 54% were noise-related and the other 46% were patient factors, with up to half of the total sleep occurring during the day. Nearly 40% of ICU patients from another investigation reported being unable to sleep in the ICU, both from difficulty falling asleep and waking in the middle of the night, and the subjects further remarked that this represented a moderate or extreme “bother” during their stay in the unit.<sup>13</sup> In a small study, 9 postoperative surgical ICU patients underwent 4 days of continuous PSG monitoring, which also confirmed severely decreased total sleep time (83–228 min of sleep per day), with predominantly (40%) stage 1 and only 5% REM-stage sleep.<sup>14</sup> A noteworthy finding was that the parallel assessment of sleep by the nursing staff reported nearly normal mean total sleep time of near 6 hours, when actual mean total sleep time was less than 3 hours. This emphasizes the inferior nature of more commonly used subjective interview and questionnaire techniques typically used to record patient sleep behavior in the hospital.

Alternative surrogate techniques to assess sleep in the hospital ward area and in the ICU have also been utilized, such as actigraphy which measures the level of activity at the wrist to discern wakefulness judged by “movement” and rest or sleep state estimated from “stillness.” Actigraphy was tabulated for 72 hours in 14 ICU patients and

compared to 6 general medical ward patients, and showed that the ICU patients slept very little and erratically, while ward patients slept 7.5 hours per day.<sup>15</sup> When 22 women were examined using actigraphy over a 6-month period after coronary artery-bypass-graft surgery, the data indicated nighttime sleep was very disrupted and finally became less fragmented and more consolidated during nighttime hours over a period of 24 weeks.<sup>16</sup> Those authors concluded that their data indicated the importance of interventions to improve sleep during and after hospitalization to optimize recovery.

The disruption of the circadian rhythm and variation of melatonin secretion levels in hospital patients have been investigated using the melatonin urinary metabolite 6-sulfa-oxymelatonin (6-SMT). Melatonin is released from the pineal gland, except when inhibited by light, so it is found at low levels during daylight hours and peaks between 1 AM and 3 AM; therefore, 6-SMT is at its apex a few hours later.<sup>17</sup> When patients admitted to the ICU for several days were investigated and urine was continuously collected for a 24-hour period, the diurnal variation in 6-SMT levels disappeared and the secretion pattern was low and essentially flat.<sup>18</sup> The loss of normal circadian rhythm pattern by this assay was further supported by simultaneous actigraphy measurements.

### Sleep in Selected Medical and Surgical Conditions

#### Coronary Disease, Heart Failure, and Stroke

A study reported findings in 12 patients after sustaining an acute myocardial infarction who underwent nightly PSG recordings in the ICU and thereafter on the ward, and compared this to matched controls.<sup>19</sup> When the ICU patients were compared to controls, similar results were noted, as discussed earlier in other ICU patients; there were significant differences, with increased wakefulness, more arousals and sleep-stage shifts, low percentage of REM sleep, and an absence of the usual circadian variation in heart rate. The differences faded over time, with transfer to the hospital ward, but subsequent anginal attacks peaked at day 4–5 and occurred more often in REM sleep. Although not clearly attributed to OSA, oxygen desaturations were examined in 19 consecutive patients with acute myocardial infarction who were continuously observed nocturnally with Holter monitors and pulse oximetry.<sup>20</sup> Oxygen desaturations to < 80% were documented in most patients, with simultaneous episodic ST segment deviation and/or arrhythmias (supraventricular, ventricular ectopy, and atrioventricular blockade), and occurred with the highest frequency in the first 2 nights but continued over the next 5 nights. More recently, large epidemiologic studies have confirmed the association of nocturnal arrhythmias with

sleep-disordered breathing in the Sleep Heart Health Study.<sup>21</sup>

Large epidemiologic studies have established that OSA is a risk factor for stroke and death, but it is also well known that there is a high prevalence of OSA in patients after a stroke.<sup>22,23</sup> Two independent investigations revealed that PSG-proven OSA was present in 63% of stroke patients and only 13% of control subjects, or in 77% of men versus 64% of women with recent strokes, compared to controls, with 23% men versus 14% women.<sup>24,25</sup> Apnea in stroke patients has been significantly and independently related to duration of hospitalization and lower functional independence measure scores at hospital admission and discharge.<sup>26,27</sup>

### Sepsis

Sepsis has an adverse effect on sleep, but the pathogenesis is incompletely explained. There is an increase in sleep-promoting cytokines such as tumor necrosis factor and interleukin-1 $\beta$ , but there is an increase in non-REM sleep and decreased REM sleep.<sup>28</sup> There is a characteristic electroencephalographic (EEG) appearance of septic encephalopathy, with low-voltage, mixed-frequency waves with variable theta and delta frequency, and this has been demonstrated in septic patients or those who had positive blood cultures during EEG monitoring.<sup>29</sup> These EEG changes might be considered as an early marker for the septic condition.

There is a loss of the normal circadian melatonin secretion in sepsis, which was noted above, and can be monitored by its urinary metabolite, 6-SMT. A study was undertaken where all patients were provided darkening masks from 10 PM to 6 AM and compared 17 septic sedated ICU patients with 7 non-septic ICU patients, and 21 control patients, who were assessed with urinary 6-SMT.<sup>30</sup> There was a loss of the periodic 6-SMT excretion in the awake septic ICU patients, and this was replaced by a more-continuous stimulation of melatonin production; the melatonin excretion remained abnormal for many weeks after recovery from sepsis. Reduction in REM sleep may be protective, as it is usually associated with oxyhemoglobin desaturation, and steady melatonin secretion may also be advantageous because of its known benefit on reducing oxygen radicals generated during sepsis.

### Postoperative Circumstances

#### General and Abdominal Surgery

There is a reduction in REM sleep in most hospitalized patients, but in surgical patients it is nearly completely obliterated during the immediate postoperative period. It is known that catecholamines and cortisol levels rise sharply

in the early postoperative period and can inhibit REM sleep, but the most powerful suppressant is probably the effect of opioids.<sup>31</sup> Oxygen desaturations occur frequently in the postoperative period and appear most pronounced on the second and third postoperative nights. Episodic desaturations have been linked to REM rebound and are seen even in healthy, non-sleepy, non-obese patients after major orthopedic, abdominal, and thoracic surgery.<sup>32,33</sup>

#### Cardiac Surgery

Studies have been done to evaluate the sleep disturbances that occur after open heart surgery and compared to a group of thoracotomy patients after partial or complete pneumonectomy not involving cardiopulmonary bypass, using all-night PSG for up to 5 weeks.<sup>34</sup> The open heart surgery patients demonstrated significant suppression of both REM and slow-wave sleep, and in the thoracotomy patients these sleep findings returned to preoperative levels much sooner. Open heart surgery patients experience both acute and chronic disruptions of sleep that last well beyond the hospital period of convalescence. One can assume that these sleep disturbances have considerable relevance for postoperative management.

Melatonin and cortisol secretion was described in 12 male perioperative coronary artery bypass surgery patients for 3 days.<sup>35</sup> The melatonin and cortisol secretion was disrupted during cardiac surgery and in the immediate postoperative period, but the circadian secretion pattern of melatonin was present in most patients by the second postoperative day. The circadian rhythm of cortisol secretion, however, was regained in only 30% of the patients by postoperative day 2. In contrast, the 22 women, examined using actigraphy after coronary artery bypass graft surgery, as noted above, had very disrupted sleep for up to 24 weeks, so there may be sex-related differences during recovery.<sup>16</sup>

#### Orthopedic Surgery

In order to evaluate a uniform population of surgical patients for postoperative complications, a study was done on 101 patients undergoing hip or knee replacement and diagnosed with OSA (mean apnea-hypopnea index [AHI] approximately 40 events/hour) < 3 years prior to or subsequent to the operation.<sup>36</sup> Results from 101 matched control patients without OSA undergoing the same operation were compared. Interventions for complications were tabulated, and included hypoxemia, acute hypercapnia, episodes of delirium, and unplanned ICU days, re-intubations, and cardiac events. Complications were noted in 39% of patients in the OSA group and 18% control-group patients ( $P = .001$ ), whereas serious complications occurred in 24% versus 9% in the OSA versus control pa-

tients ( $P = .004$ ). The OSA patients also added nearly 2 extra hospital days (mean 6.8 d vs 5.1 d), compared to the control patients ( $P < .007$ ).

### **Sleep-Disordered Breathing in Mechanically Ventilated ICU Patients**

Sleep disruption in the ICU can be profound, as described above, but the specific effect of mechanical ventilation on sleep has also been investigated.<sup>37,38</sup> When 20 critically ill and mechanically ventilated patients underwent 24-hour continuous PSG studies, 3 groups were identified, including those who were “disrupted” (equivalent proportions of non-REM and REM sleep throughout the day); “atypical sleep” (transitions from stage 1 to stage 3 sleep, with absence of stage 2 and reduced REM-stage sleep); and “coma” ( $> 50\%$  delta or theta EEG activity, with and without evidence of EEG activation spontaneously or with deep painful stimuli).<sup>39</sup> Sleep efficiency overall was 38%, and the atypical sleep and coma groups received higher doses of sedative medications and had a higher acute physiology score than the disrupted-sleep group. Noise distractions are known to be a component of the sleep disruption, but the majority of this is not explained by noise and scheduling distractions.<sup>29</sup> Additionally, patients requiring neuromuscular blockade and mechanical ventilation have been shown to be awake nearly 25% of the time but have no detectable REM sleep.<sup>40</sup>

There may be an effect of ventilator mode on sleep and breathing in patients undergoing mechanical ventilation, as demonstrated in 11 critically ill patients during one night of sleep.<sup>41</sup> Greater sleep fragmentation was observed during pressure support than during assist-control ventilation. Six of those patients developed central apneas during pressure support but not during assist-control ventilation, and patients with apnea were more likely to have heart failure (83% vs 20%). Also, the patients who developed central apneas during pressure support had a substantial decrease in the arousals and awakenings with the addition of dead space as sleep efficiency also increased.

A randomized crossover study using proportional-assist ventilation versus pressure-support mode was done in 13 patients during weaning from mechanical ventilation to evaluate whether improved patient-ventilator synchrony could reduce sleep disruption.<sup>42</sup> Overall sleep quality was significantly improved on proportional-assist ventilation ( $P < .05$ ) and associated with fewer arousals and awakenings per hour as well as more REM and slow-wave sleep. The proportional-assist ventilation mode allowed a greater increase in  $P_{aCO_2}$  during the night, since tidal volume and minute ventilation were lower, also leading to fewer patient-ventilator asynchronies per hour, which correlated with the number of arousals per hour ( $P < .001$ ). This suggests that patients on pressure-support mode may

have a tendency to be over-ventilated at times and then develop periodic breathing and worse sleep disruption, compared to other flow delivery methods.

Of special interest was a study that asked if sleep quality could help predict noninvasive ventilation (NIV) outcome in patients with acute hypercapnic respiratory failure, which also sought to identify factors that may predict or explain late NIV failure.<sup>43</sup> The investigators prospectively evaluated 27 hypercapnic patients requiring NIV in an ICU with PSG over 17 hours, recorded between 48 to 96 hours after NIV was initiated. Abnormal ambiguous EEG patterns were seen in 7 of the 14 patients, with late NIV failure defined as death, endotracheal intubation, or persistent need for NIV on day 6, compared with only one of the 13 patients successfully treated with NIV ( $P = .03$ ). Patients successfully treated with NIV had better sleep quality, with less circadian sleep-cycle disruption and more nocturnal REM sleep (26 vs 6 min,  $P = .03$ ), compared with patients who failed NIV, which was also associated with more ICU stay delirium (64% vs 0%).

### **Management of OSA in the Perioperative Period**

#### **Medical Society Recommendations**

The American Academy of Sleep Medicine (AASM) Clinical Practice Review Committee did a literature search pertaining to non-upper-airway surgery in OSA patients between 1985 and 2001 and concluded that there was insufficient information to develop AASM standards of practice recommendations.<sup>44</sup> They therefore produced a consensus statement suggesting important components of the perioperative management of OSA patients who should be considered. They urged that there be a high degree of clinical suspicion for OSA and that aggressive efforts take place to control the airway throughout the perioperative period. They encouraged very judicious use of medications, particularly opioids, and that appropriate monitoring be employed to allow early intervention of any postoperative complications.

The American Society of Anesthesiologists (ASA) also formed a task force to create guidelines that focus on the perioperative management of patients with OSA who may be at increased risk for perioperative morbidity and mortality.<sup>45</sup> They sought to give more precise direction for the identification and management of OSA patients undergoing surgery. The group urged the development of preoperative protocols to screen patients suspected of having OSA based on history-and-physical findings. The specific intraoperative suggestions included consideration of local or regional procedures in favor of general anesthesia. They recommended that continuous monitoring be done for any assisted ventilation during moderate sedation and that patients be extubated only when they are fully awake. In the

postoperative arena, they advised avoidance of continuous-infusion opioids. Any concerns should prompt use of telemetry or even ICU admission, but no specific criteria were presented.

### Questionnaires

Several questionnaires have been developed to aid in the identification of patients at risk for OSA, and have primarily been validated for out-patients in a sleep laboratory environment, but a few of these questionnaires have been tested in preoperative patients.<sup>46</sup> A systematic review was carried out to identify and evaluate the available questionnaires for screening of OSA patients and was assessed using the Cochrane Methods Group's guidelines. There were 10 studies with a total of 1,484 patients included, and the Berlin and Wisconsin sleep questionnaires were the top 2 most commonly used. In the 4 studies done on "sleep-disorder patients," the pooled sensitivity and specificity were 72% and 61%, respectively. They concluded that although the evidence supporting the accuracy of OSA screening questionnaires was promising, it was nevertheless inconsistent, probably due to heterogeneous design for population, questionnaire type, and validity. The STOP-BANG (Snoring, Tiredness, Observed apnea, and high blood Pressure - Body mass index, Age, Neck circumference, and Gender) questionnaire was suggested because of its high methodological quality and easy-to-use features. The STOP portion classified 28% of nearly 2,500 pre-surgical patients as being high risk-for OSA, and about 10% went on to have PSG studies, to confirm a sensitivity of 74.3% for predicting OSA with AHI > 15 events/hour.<sup>47</sup> When incorporating the BANG components the sensitivity at the same AHI level increased to 92.9%.

Studies like these provoke many questions. How do we decide who is most at risk—that is, who should we screen and what are the warning signs? Clinicians are trying to identify patients with OSA because it is believed that they are at high risk for postoperative complications, so the complication risk and not OSA is seemingly the more important item to predict with accuracy. Once increased risk of postoperative complications is suspected, what is the correct and necessary monitoring, and should all monitoring be based on risk stratification? Finally, the effectiveness of any monitoring is linked to an appropriate response, so what interventions will be helpful? Should anesthetic techniques be altered, and is there a role for preemptive positive airway pressure (PAP) therapy?

A follow-up retrospective investigation was initiated to validate the Berlin questionnaire and the ASA checklist in surgical patients, and then was planned to compare these with the aforementioned STOP questionnaire.<sup>48</sup> The Berlin, ASA checklist, and STOP questionnaires classified patients as high risk for OSA, showing frequencies of

33%, 27%, and 28%, respectively, with parallel sensitivities for OSA in 177 patients who underwent PSG of 68.9–87.2%, 72.1–87.2%, and 65.6–79.5% at AHI cutoffs between 5 to 30 events/hour. In patients classified as being at high risk of OSA by the STOP and ASA checklist who also had an AHI > 5 events/hour, there was an increased number of postoperative desaturations and need for prolonged oxygen therapy. None of the questionnaire-based studies was able to predict cardiac complications, need for unplanned ICU admission, or prolonged hospital stay.

A different simple OSA screening questionnaire, called the Sleep Apnea Clinical Score (SACS) was validated in the out-patient sleep laboratory environment and shown to have a high positive predictive value for OSA.<sup>49</sup> The SACS score was initially validated in post-surgical patients to identify patients who desaturated in the postoperative hospital ward area.<sup>50</sup> A large follow-up prospective study enrolled nearly 700 patients using the SACS and showed that a higher risk of OSA (31.9%) was associated with a much higher likelihood of a postoperative 4% oxygen desaturation index greater than 10/h and recurrent post-anesthesia care unit respiratory events.<sup>51</sup> Subsequent postoperative hospital ward episodes of respiratory complications were also associated with a high SACS (odds ratio 3.5,  $P < .001$ ), especially if they also had recurrent respiratory events in the post-anesthesia care unit during 90 min of observation, whereby the likelihood of a postoperative respiratory event was markedly increased (odds ratio 21.0,  $P < .001$ ). Again, there was no significant benefit with the SACS questionnaire in predicting cardiac complications or prolonged hospital stay.

### Monitoring

#### Oximetry

Continuous pulse oximetry is considered a standard of practice and is widely used in the perioperative period in hopes of averting postoperative complications and improving patient outcomes by enabling rapid interventions to correct these events. A database search of controlled trials that randomized patients either to pulse oximetry or to no pulse oximetry during the perioperative period was undertaken to assess the ability of pulse oximetry to identify preventable adverse outcomes or improvable situations.<sup>52</sup> Data from 5 reports and a total of 22,992 patients who were eligible for analysis showed that hypoxemia was reduced in the pulse-oximetry group, both in the operating and recovery rooms, and the incidence was 1.5 to 3 times less for the pulse-oximetry group in the recovery room. In patients recovering from cardiothoracic surgery in a general care area, no statistically significant differences were detected in cardiovascular, respiratory, neurologic, or infectious complications in the 2 groups, and routine oxim-

etry did not reduce transfer to an ICU, duration of hospital stay, or overall mortality. These studies revealed that perioperative monitoring with pulse oximetry can reduce pulmonary events and did result in improved patient outcomes.

Home oximetry has also been used to screen patients for potential postoperative complications. A study was done in 172 patients with clinical signs of OSA during preoperative assessment for elective surgery, to investigate the relationship between a 4% oxygen desaturation index by home nocturnal oximetry with the occurrence of postoperative complications.<sup>53</sup> The home nocturnal oximetry testing showed that 57% of the patients who had a 4% oxygen desaturation index  $\geq 5/h$  also had a significantly higher rate of postoperative complications, versus patients with a 4% oxygen desaturation index  $< 5/h$  (15.3% vs 2.7%,  $P < .01$ ) with an adjusted odds ratio of 7.2. Overall, there were few events, and most of the complications were respiratory in nature and merely involved need for more supplemental oxygen. The home oximetry did not predict hospital stay, other complications, and did not result in major improved outcomes.

### Capnography

With the lack of demonstrated outcome benefit in perioperative patients from oximetry, others have turned to alternative monitoring techniques. The accuracy of end-tidal carbon dioxide tension and transcutaneous carbon dioxide monitoring was evaluated in a sleep laboratory, with comparison of  $P_{aCO_2}$  levels in patients breathing room air, receiving supplemental oxygen via nasal cannula, or receiving nocturnal positive-pressure ventilatory assistance.<sup>54</sup> The utility of end-tidal carbon dioxide tension and transcutaneous carbon dioxide appeared questionable, as they did not accurately reflect the simultaneous  $P_{aCO_2}$  levels while monitoring patients during diagnostic and therapeutic sleep studies, most importantly when PAP therapy was applied. Both end-tidal carbon dioxide tension and transcutaneous carbon dioxide have therefore been regarded as more valuable to verify trend behavior rather than absolute values of  $P_{aCO_2}$  levels.

In order to evaluate the value of capnography in patients with and without OSA during recovery from general anesthesia, an investigation was undertaken to evaluate the accuracy of oral guide nasal cannula with a sidestream capnometer, as compared to an arterial carbon dioxide partial pressure that was determined simultaneously.<sup>55</sup> Findings were similar in obese and non-obese patients. Mainstream capnometry was superior to sidestream capnometry, but the outcome benefit and predictability of adverse consequences was not evaluated. Whether capnography has any advantage over oximetry in the management of postoperative patients remains to be proven.

## Interventions

### Sleep Interventional Protocols

Given all the above considerations of the deleterious effects of sleep deprivation and sleep-disordered breathing in hospitalized patients, it is not unexpected that there have been attempts to develop interventional protocols to improve these problems.<sup>39</sup> Sleep enhancement techniques have been urged, and many simple interventions are easily employed, beginning with attention to noise reduction. An array of suggestions include limiting televisions and phones in the ICU and keeping patients' doors closed, as well as posting signs to remind staff and visitors to minimize noise and conversations near the room. One could consider liberalizing or dulling monitor alarms and perhaps switching to central monitoring personnel if appropriate. Staff in many cases could switch beepers to "vibrate" at night and patients may benefit from use of ear plugs or addition of background white noise.<sup>56</sup> Patient care activities should be done in a way to promote adherence to a normal circadian rhythm pattern, with avoidance of nocturnal radiographs and blood tests. Support of a more normal circadian rhythm pattern, with bright light during the day and darkness after 10 PM is also encouraged. Attention to ventilator settings may also be useful, as described above.

Minimizing use of benzodiazepines and consideration of alternative sleep medication aids has also been explored. A randomized double-blind placebo-controlled trial comparing oral melatonin 10 mg or placebo over 4 nights was conducted in 24 patients who had undergone a tracheostomy for prolonged mechanical ventilation.<sup>57</sup> In the placebo group, nocturnal sleep time was only 2.5 hours, but the melatonin use was associated with a 1-hour increase in nocturnal sleep and "better" sleep ( $P = .04$ ). Another study with melatonin administration was a crossover trial that used actigraphy on 8 hospitalized COPD patients and showed baseline sleep was reported to increase to near 6 hours, but the comparison between melatonin and placebo did not report positive results.<sup>58</sup>

### Intervention Protocols in General and Orthopedic Surgical Patients

An obvious consideration to explore in patients with sleep-disordered breathing is whether preemptive or protocol-directed PAP therapy for predicted or identified sleep-disordered breathing will improve outcome. Anecdotal reports in a small number of patients have proposed such a protocol. A paper by Bolden et al discussed important issues in OSA patients that occurred prior to and after implementation of an OSA protocol, although no large-scale outcome data were available from that study.<sup>59</sup>

Early in the 1990s a postoperative death occurred after a respiratory arrest in an untreated OSA patient, and a subsequent patient had serious postoperative complications aborted with continuous PAP (CPAP). These events resulted in the initiation of a hospital-wide protocol to treat all postoperative patients with CPAP.<sup>60</sup> The next 14 OSA patients were started on CPAP before surgery and immediately after extubation nearly continuously for 24 to 48 hours, and thereafter for all sleep periods. None of these patients had major respiratory complications, leading those authors to conclude that serious efforts should be made to identify OSA patients, and that CPAP should be instituted before and after surgery.

Another prospective investigation was undertaken in patients undergoing orthopedic surgery to evaluate the efficacy of the SACS score in predicting which high-risk OSA patients may have postoperative sleep-related desaturations or a respiratory disturbance index > 15, and could perhaps benefit from preemptive CPAP treatment.<sup>61</sup> Qualifying high-risk patients based on the SACS were randomized to receive postoperative usual care or usual care plus auto-titrating CPAP; 33 patients were randomized to the high-risk group for sleep apnea and 9 were enrolled in the low-risk observation group. The SACS had a sensitivity of 85% for selecting patients who will have a postoperative respiratory disturbance index  $\geq$  15. Patients who were at a low risk score still had significant desaturation and respiratory events on the first postoperative night, but they were less severe than those in the "high risk" group. The percentage time spent below 90% oxygen saturation is even higher on the night prior to discharge (usually postoperative night 4) than on the first postoperative night, which may be related to more REM sleep stage on the night prior to discharge, and empirical supplemental oxygen is often discontinued by that time. No difference in outcome could be demonstrated by preemptive CPAP use in the high-risk patients, largely because more than 50% of the patients would not comply with the CPAP use. It is not difficult to recognize that patients with substantial postoperative pain issues asked to utilize CPAP treatment for the first time in this situation may not adhere to therapy.

### **Intervention Protocols in Gastric Bypass Surgery Patients**

The severely obese patient is already predisposed to postoperative complications such as sleep-disordered breathing, atelectasis, gas-exchange abnormalities, and ineffective secretion clearance. A prospective, multicenter, observational study in consecutive patients undergoing bariatric surgical procedures at 10 United States clinical sites was done with a target composite end point of 30-day major adverse outcomes.<sup>62</sup> Factors that were independently associated with an increased risk of the composite end point included a

history of deep-vein thrombosis or pulmonary embolus, impaired functional status, and a diagnosis of OSA.

The use of CPAP or bi-level PAP (BPAP) has proven effective for treatment of all of these problems, but for patients after upper gastrointestinal surgery it has not been universally adopted because of reports that the air pressure can lead to massive bowel distention and subsequent development of anastomotic leaks.<sup>63</sup> Others have challenged the need for PAP therapy in these patients and reported comparable outcomes between known OSA patients using preoperative PAP therapy or not, and also patients with no history of OSA.<sup>64</sup> In that review the largest number of patients (811) had no known history of OSA, and of the 284 patients with a confirmed diagnosis of OSA, 144 were PAP-therapy-dependent. No anastomotic leaks or deaths occurred, and there was only one pulmonary complication noted in the OSA group on PAP therapy, 3 in the OSA non-PAP group, and 6 in those not known to have OSA.

Most clinicians do not adhere to this philosophy, and not only feel that the risk of pressurized air complications is over-exaggerated but urge that the benefit of postoperative PAP therapy in those who need it is clear. A prospective study was done to evaluate the risk of developing anastomotic leaks and pulmonary complications and to assess the safety and efficacy of postoperative CPAP after a Roux-en-Y gastric bypass procedure.<sup>65</sup> There were a total of 1,067 patients undergoing Roux-en-Y gastric bypass, and 420 had OSA and 159 were using CPAP. There were no episodes of pneumonia diagnosed in any of the patients, whereas only 2 of the 15 major anastomotic leaks occurred in the patients treated with CPAP, and there was no correlation between CPAP use and major anastomotic leakage ( $P = .6$ ). Additionally, there is evidence that PAP therapy has a beneficial effect on pulmonary function in patients following gastric bypass surgery with BPAP.<sup>66</sup> There were 27 patients randomized to receive BPAP or conventional postoperative care who had pulmonary function tests done before and after surgery. Expiratory flow was decreased in both groups, and there was no significant difference preoperatively between the groups. On each of the 3 consecutive postoperative days in the patients who received BPAP therapy, the forced vital capacity and FEV<sub>1</sub> were significantly higher, and the oxygen saturation was significantly decreased in the control group. Despite the improved pulmonary function, BPAP use did not result in fewer hospital days or a lower complication rate in these otherwise healthy obese patients.

### **Intervention Protocols in Congestive Heart Failure**

In patients with congestive heart failure and OSA the use of CPAP is associated with improvement in oxygenation and decreased sympathetic nerve activity and afterload, which can lead to an increase in systolic function in patients with advanced congestive heart failure.<sup>67,68</sup> Treat-



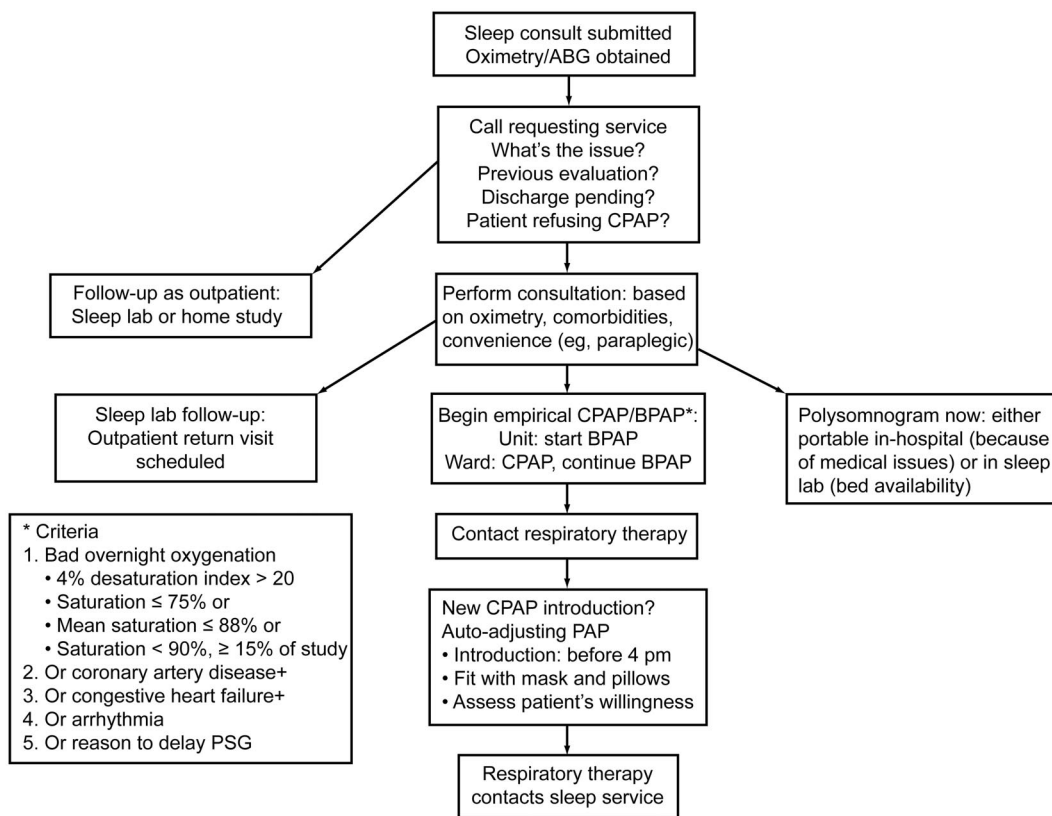


Fig. 2. OASIS: Obstructive Apnea Systematic Intervention Strategy approach for evaluating a medical or postoperative patient for sleep apnea. ABG = arterial blood gas. CPAP = continuous positive airway pressure. BPAP bi-level positive airway pressure. PSG = polysomnography.

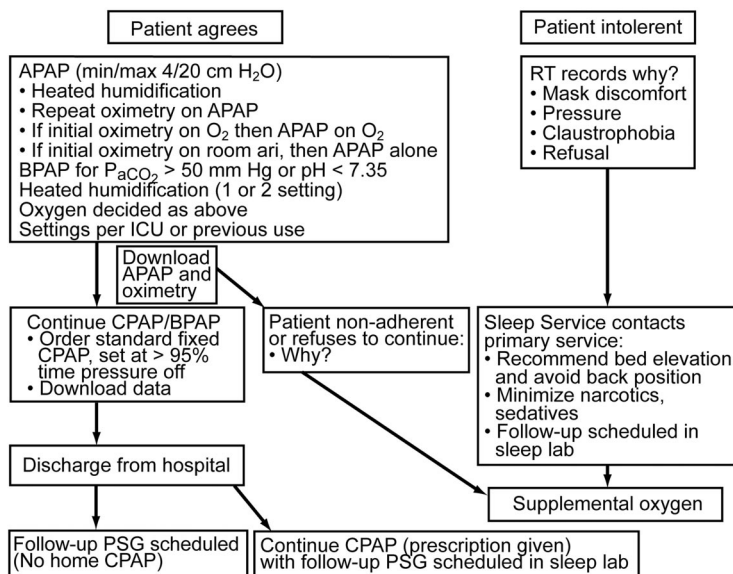


Fig. 3. Positive airway pressure (PAP) therapy continuation decision pathway. APAP = auto-adjusting PAP. BPAP = bi-level PAP. PSG = polysomnography. RT = respiratory therapy.

ment with CPAP has also been studied in 46 consecutive hospitalized patients with acutely decompensated heart failure.<sup>69</sup> In order to identify the patients with sleep-disordered breathing, all underwent an attended in-hospital sleep study within the first 2 days of hospital admission. This revealed that 46 consecutive patients had OSA with an AHI > 15 events/h, and all received standard care for congestive heart failure but were then randomized to receive auto-adjusting PAP or only standard care. There was no improvement in left-ventricular ejection fraction from baseline to 3 days post-randomization in the standard-care group, but the auto-adjusting-PAP arm showed a significant difference ( $P = .03$ ) in left-ventricular ejection fraction improvement of 4.6%, and this persisted after adjustment for baseline left-ventricular ejection fraction, type of cardiomyopathy, body mass index, AHI, and sex.

### Summary

Sleep and sleep quality are more difficult to measure in the hospital setting, and for that reason other means of assessment, such as actigraphy or urinary metabolites of melatonin, are used as surrogates. As described above, sleep is severely disrupted in hospitalized patients, especially in the medical ICU, with sepsis, and in mechanically ventilated patients, and can result in a complete obliteration of the normal circadian rhythm pattern. There is clearly a need for sleep enhancement protocols and further studies to assess outcome benefits of these efforts. In postoperative patients the sleep is most profoundly affected in the first few days after surgery, with near absence of REM sleep, and this seems to correlate most closely with the use of high-dose opioids.

Patients at high risk for sleep-disordered breathing may have a prevalence of near 30% in the postoperative situation, and questionnaires have helped guide outcome prediction with a high positive predictive value. We have had the most success with the SACS, but the most commonly used STOP-BANG questionnaire has proven useful in predicting both the likelihood of OSA and postoperative respiratory complications. Regardless of what method is used, ASA and AASM guidelines have urged that attempts be made to identify patients with OSA preoperatively and to subsequently employ appropriate monitoring techniques to avoid postoperative complications.

It is not known whether "just-in-time" PAP therapy intervention in the hospital patient with OSA has an influence on outcome, but some benefit has been shown in patients with congestive heart failure and after gastric bypass surgery. We have established in-hospital sleep consultative services and an obstructive apnea systematic intervention strategy (OASIS) protocol to deal with patients with suspected OSA (Figs. 2 and 3). Initial decision making is based on discussion with the primary requesting

service and a current overnight oximetry and arterial blood gas as indicated. A diagnostic and therapeutic split-night PSG may be ordered right away or delayed until discharge. If the oximetry and arterial blood gas are more concerning, empirical PAP therapy can be initiated either on the hospital ward or in a more strictly monitored unit, as needed. The patient's tolerance of PAP therapy and willingness to continue treatment dictates the pathways outlined in Figure 3. The OASIS protocol can be applied with equal ease to either medical or postoperative patients. Many hospitals throughout the country have adopted their own approaches to monitoring and treatment of patients with suspected or observed sleep-disordered breathing, and it is likely that this issue will become a future element for judging best practice performance. Those that are aggressive and successful with these efforts are likely to reap the benefits of reduced complications and lower costs.

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## Discussion

**Pierson:**\* I'd like to follow up on the last recommendation that you left us with, about protocols for handling sleep-disordered breathing in the acute-care setting. At Harborview, where Vishesh and I practice, we don't do much elective surgery, and it's by-and-large an adult acute-care hospital. A patient with previously undiagnosed OSA who's hospitalized there for any reason is almost certain to have one or more "rapid responses" called, and will typically get a CT [computed tomography] angiogram and other expensive studies to see what the acute respiratory process is, when all they're doing is manifesting their underlying sleep-disordered breathing. It becomes a very practical and almost daily issue

for the respiratory therapy department as well as for the pulmonary consult service.

Once the patient has had a CT [computed tomography] angiogram and the various other studies and everybody is convinced that the patient has not just had a pulmonary embolism or developed pneumonia or something, what do we do next? Do we try to just reassure people and say, "It's OK, this can be worked up later?" because that's very difficult to do whenever anybody sees a saturation less than 90% in the acute-care setting. Should we just empirically put them on some sort of PAP therapy? Or should we do some sort of urgent in-hospital diagnostic test, recognizing that in that acutely ill state the results may not be applicable once they are out of the hospital and stable?

**Gay:** I appreciate this question, because I saved this for the discussion. We started a study looking at preoperative patients at high risk for OSA, using the Flemons criteria, and we ran-

domized them to receive either postoperative empirical CPAP using an autoCPAP when in the hospital or "usual care." Two things came out of that:

1. It's amazing to me how many of these patients desaturate in the postoperative period, and we just turn up their oxygen and go on our merry way. In fact, we did portable-monitoring "sleep" studies on some of these patients, and they're still desaturating on the day they go home. For whatever reason, patients tolerate this kind of behavior a lot, and I want to make the point that I'm not really trying to open up a CPAP clinic in the hospital; that is, I'm not just trying to diagnose OSA there. That's an out-patient event. Fundamentally, I'm trying to identify patients who will have a complication, and I want to be taking care of them and monitoring them before they get into a bad situation. So it's a bit misguided when we try to sell this argument that we're looking for OSA: we're not.

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2. So now let's look at those same patients we preemptively gave auto-CPAP to. More than 50% of them threw it on the floor. It was impossible to get them to use it. Postop, when somebody's miserable, they hurt, and their sleep is terrible, is not the time to try to introduce a treatment method that's brand new to them. It's quite a struggle to take that kind of approach, so oftentimes it's a matter of oxygenating them and then bringing them into a more monitored situation, and we use a telemetry unit now. Some of them you have to use PAP therapy, but the majority are not going to like it. That is the main reason we never completed the study.

**Pierson:** As you said, most patients in those circumstances tolerate desaturation very well, but I can tell you that our nurses don't! That's because in the acute-care setting they've been trained to respond to physiologic changes to try to avert catastrophe. It's a practical issue on a daily basis: how to permit desaturation to occur in the hospital and have it not be the trigger for a bunch of interventions.

**Gay:** And there I think telemetry units are a double-edged sword; we're saying, "OK, at least we're monitoring them," but the majority of people will be treated with simply a high level of supplemental oxygen.

**Dhand:** To extend that question, we face the situation very commonly when the patient is in the unit and they seem to have obstructive events and oxygen desaturations. Later, they get transferred to the floor, and they're going to go home. Do we empirically give them a level of CPAP? Our sleep lab is very reluctant to do in-patient studies, so what kind of protocol would you recommend in that situation?

**Gay:** Basically, where there is more serious desaturation and people are convinced that this does have an association with undiagnosed severe

OSA, our sleep group will come see that patient while still in the hospital. We try to get them oxygenated appropriately, observe the situation, and we'll do one of 2 things.

We'll introduce them in the light of day to an auto-titrating CPAP device. If they are tolerant of that, we let them go that night and use it, download it, and look at the downloaded information and overnight oximetry that we can get from that night and decide about what to do next. About 90% of the time it's a Medicare patient.

If we do a sleep study in the hospital, that's a triple hit. The one technician who was going to do 2 studies in the lab that night is now coming over to do a hospital study that we're not getting paid for at all, so it's a triple loser. So we almost never do formal sleep studies in the hospital, and we'll discharge them the night that they're ready to go home and go straight to the sleep lab. We'll prioritize them based on, say, hypercapnia, bad oximetry, and who should really be going home with a device rather than waiting 2 weeks to come back to see in the lab. We also follow these people, and about 50% are never seen again. So even if you make the observation, half of them you're never going to see again. It's a challenging situation, to say the least.

**Parthasarathy:** You showed that patients with a high chance of having OSA have a higher likelihood of other postoperative complications. There seem to be other aspects as these data are evolving that we need to be cognizant of. You brought up economic concerns, and there seems to be a liability concern. There was some rumor that the Joint Commission was going to come up with a mandatory preoperative screening for sleep apnea, and then it just fell off the radar at the last moment. You brought up the economics issue; but is there a liability issue in a patient who has witnessed apneas and desaturations and refuses to use CPAP? Is there a

liability concern of discharging such patients without getting them to be adherent to CPAP therapy, especially when we know that they have higher risk of postoperative respiratory complications?

**Gay:** All the more serious liability situations that I know of are not failure to bludgeon somebody into using CPAP who was just totally objecting to it. It was failure to respond through a chain of letting people up the ladder know that this patient is desaturating and refusing to use the equipment.

In our situation, probably the most challenging is the bariatric surgery patients. Every one of those are seen preoperatively, either in the sleep lab or at least has some kind of screening procedure done and need CPAP. Some of those patients are so happy when they get their surgery that they don't want to wear their CPAP while still in the hospital. Those are the patients who we no longer have the option of saying, "Well, OK, hopefully you won't desaturate too badly without CPAP," because we know many will. If they refuse their CPAP, their physicians are informed; they're moved to telemetry if they were really bad before that.

I think it's more about the necessary chain of command being informed, but, ultimately, a patient can refuse a therapy as long as you've gone to the effort to say, "Look, we've gone all through this, we really think you should do this, but if you don't want to do it, that's your liability."

**Dhand:** You mentioned that a lot of the hospitalized patients sleep in the daytime, but they don't get their CPAP during the daytime, probably because it's supposed to be nocturnal therapy. I suppose we need protocols that state that the CPAP should be applied *whenever* the patient is sleeping rather than only during the night.

**Gay:** I agree.

**Bollig:** I have a question regarding the care of the patient with potential sleep apnea in the acute-care setting. In his presentation Dr Kapur talked about the prevalence of OSA and sleep-disordered breathing, which in the worst-case scenario is 9–24% of our general population, and I think in the acute-care setting that prevalence is much greater. The people we see in the acute-care facility are older, sicker, and have a lot of the comorbidities associated with sleep-disordered breathing. So when you raise the questions of who should we be screening, and how should we be looking at this condition in the acute-care center, I would venture to say that we should screen every admission and that questioning their sleep habits or potential signs and symptoms of sleep-disordered breathing should happen on every patient intake questionnaire. Certainly in the preoperative patient I think it would go without saying.

One of the things we considered in my institution was the idea that a large percentage of the people we see, because we're a rural referral facility, are quite ill—many with heart conditions, and many coming in for total hip or knee replacement. The incidence of sleep-disordered breathing was something I brought forward at our institution some years ago, even before the anesthesia preoperative guidelines came out.

It needed to be addressed, not because we needed to identify more sleep patients or have more business in the sleep testing facility, but from a risk-management and liability point of view. I think most acute-care facilities are looking at that as a way of doing business, because patient outcomes and patient safety are a huge incentive for us from a financial and liability point of view.

**Gay:** We use the Sleep Apnea Clinical Score on virtually everyone who comes into a hospitalized situation. I've had a number of discussions with

others, and out-patient surgery has eclipsed (and if it hasn't at your hospital, it will soon eclipse) in-patient surgery. So what do you do with a patient who comes in for a one-day procedure and they'll be going home on narcotics, but they have a witnessed event where they're really desaturating in the post-anesthesia area? You need a protocol to say, OK, a certain number of these patients in the PACU [post-anesthesia care unit] have to be admitted, and that's really a good place to look for them.

**Bollig:** I agree. We purchased auto-titration units to put into our PACU, which could be cost-prohibitive for other areas, but we're a fairly small institution. In the absence of having that technology available, at the very least your method of monitoring these patients who are at high risk for sleep-disordered breathing—especially post-anesthesia—has to really change. It has to be in the monitoring protocol, and perhaps the more judicious use of sedatives and pain medications, that we may be able to alter the risk somewhat, even if we can't convince the individual to use the positive-pressure titration unit after surgery.

**Gay:** Admittedly, what I haven't shown you with these data is that although we can now potentially identify the patients at risk of postoperative complications, what do we do to intervene? That's the hardest protocol to design right now.

**Minkley:†** I think a standardized protocol is key. I tried to implement a program in an orthopedic-surgery-based hospital. Just to make some more discrete definitions of the challenges: pre-admission screening; medical responsibility for the patient

throughout the surgical stay; and changing a "system."

The questions Do you have OSA? and Do you use CPAP? were on the preoperative questionnaire, but there was no education or pathway for what to do if the answers were yes, so there was no follow-up. So pre-admission, when there was time to intervene, they didn't get caught. When patients arrive on the day of surgery, there was another question there, but at that point nobody wanted to hold off the surgery and mess up the schedule, so they got caught, but again nothing happened.

Then we tried a basic protocol to say that if the answer to the OSA question is yes, then they should at least be seen by the physician to determine if they need to be on their therapy while they're pre-medicated in preop, as well as throughout. We found that the challenge there was that the person responsible for the medical care of the patient changes at every step along the way, so there was no one physician responsible for the continuum of care.

Then, as the patients moved through and had their surgery, the National Patient Safety Goals for pain-control became a problem because nursing was so focused on the pain ratings that the patients were well medicated, their surgery precluded them from sleeping on their side, so they were flat on their back and thus at highest risk for OSA. So many of them snored, and then that became the norm and there was no intervention.

So there were challenges all along the way, despite a lot of good reasons for intervention. As you said, about duration of stay, the PACU checks the duration of stay and tries to meet the standards, which would improve with treatment of OSA. These people who are not diagnosed or treated get missed all along the way. And the process needed to identify and treat them was just horribly difficult to implement, despite agreement on the need. I think your challenge to us of the need for a standard protocol that starts preop and

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continues all the way through postop care is probably the standard that we need to take up.

**Gay:** I totally agree with everything you've said.

**Kapur:** I want to emphasize the role of daytime hypoventilation. I think there needs to be more liberal use of blood gases in the hospitals, especially in obese individuals. I believe there's a study from the University of Colorado<sup>1</sup> that showed that individuals with hypoventilation during hospitalization had a much higher mortality rate after they left the hospital. Even though they were trying to identify these individuals and notifying house staff when hypoventilation was present, most of

them didn't get appropriate NIV [non-invasive ventilation] down the road. I think that hospitalization is a good time to identify folks we can help with therapy.

1. Nowbar S, Burkart KM, Gonzales R, Fedorowicz A, Gozansky WS, Gaudio JC, Taylor MR, Zwillich CW. Obesity-associated hypoventilation in hospitalized patients: prevalence, effects, and outcome. *Am J Med.* 2004 Jan 1;116(1):1-7.

**Gay:** Our protocol for a sleep consult includes a blood gas and overnight oximetry. The blood gas helps to distinguish those right away, because we don't initiate NIV in these folks in the hospital ward—that's so time consuming and so difficult to initiate there that they go to a respiratory care unit if they're hypercapnic.

**Patil:** In addition to issues with patients who are not diagnosed, even with identified patients whom we see in our clinic or a primary care physician's office, it's a challenge making sure they come into the hospital with their appropriate OSA therapy. One basic approach that as a field we should be looking at is educating our patients about the importance of OSA therapy around the time of surgery. That conversation should include our surgical colleagues, so the patient is motivated to bring in their CPAP, their oral appliance, or whatever treatment they have into the hospital.

**Gay:** That's a good point.