# SASM

# SASM 7TH ANNUAL MEETING
## OCTOBER 19-20, 2017
## HILTON BOSTON LOGAN AIRPORT• BOSTON, MA

## 2017
## SYLLABUS

## PERIOPERATIVE & SLEEP MEDICINE:
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# ACCREDITATION INFORMATION

## PROGRAM OBJECTIVE
The objective of this meeting is to provide a forum for discussions pertaining to the common grounds between sleep and anesthesia. The goal is to promote excellence in medical care, research and education in anesthesia, sleep medicine and perioperative medicine.

## TARGET AUDIENCE
This conference is designed for anesthesiologists, critical care physicians, residents, fellows-in-training, general medicine physicians, pulmonary physicians, sleep medicine physicians, surgeons, scientists and allied health care professionals.

## PRACTICE GAPS
The overall goal of SASM is to advance standards of care for clinical problems shared by anesthesiology and sleep medicine, including perioperative management of sleep disordered breathing (SDB), and to promote interdisciplinary communication, education and research in matters common to anesthesia and sleep.

**To identify and address present clinical practice gaps, we propose to explore the following gaps existing today in care of patients with sleep-disordered breathing:**

- Research on the topic of perioperative sleep disordered breathing remains rare and best suited study designs are sought to answer related questions.

- The adequate availability and utility of sleep laboratories to diagnose obstructive sleep apnea versus ambulatory approaches and the right approach to perioperative patients is intensely debated.

- It remains unknown if postoperative monitoring for patients with sleep disordered breathing is effective.

- The safety of opioids used in a perioperative and chronic setting in patients with sleep disordered breathing has been questioned and associated risk of complications and related mechanisms by which this patient population may be exposed to increased risk remain poorly understood.

- In the era of early recovery programs and increasing ambulatory surgical procedures the influence of sleep disordered breathing on patient selection from a medical and legal perspective remains debated.

- Evidence based guidelines regarding the intraoperative care of surgical patients with sleep disordered breathing and/or narcolepsy remain elusive.

## LEARNING OBJECTIVES

1. Discuss and understand the role of diagnostic modalities and monitoring tools for patients with sleep disordered breathing.

2. Discuss and understand the role of opioid administration in patients with sleep disordered breathing and its impact on complications.

3. Discuss and understand the impact of sleep disordered breathing on eligibility for early recovery programs and ambulatory care.

4. Discuss and understand the current evidence for the intraoperative care of patients with sleep disordered breathing and perioperative care of patients with narcolepsy.

## ACCREDITATION STATEMENT
This activity has been planned and implemented in accordance with the accreditation requirements and policies of the Accreditation Council for Continuing Medical Education (ACCME) through the joint providership of Amedco and the Society of Anesthesia and Sleep Medicine (SASM). Amedco is accredited by the ACCME to provide continuing medical education for physicians.

## CREDIT DESIGNATION STATEMENT
Amedco designates this live activity for a maximum of **12.75 AMA PRA Category 1 Credits™**. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

## FACULTY DISCLOSURES
For a full list of faculty disclosures, please see insert.

# SCHEDULE OF EVENTS

## THURSDAY, OCTOBER 19, 2017

| | |
|---|---|
| 1:00-1:05pm | **Welcome – 7th Annual Meeting**<br>*Stavros Memtsoudis, MD, PhD* |
| 1:05-3:00pm | **Research in Perioperative Sleep Medicine**<br>**Moderator:** *Babak Mokhlesi, MD, MSc* |
| 1:05-1:45pm | **Most Influential Publications in Perioperative Sleep Medicine 2015-17**<br>*Susana Vacas, MD, PhD* |
| 1:45-2:45pm | **Designing Clinical Trials in Perioperative Sleep Medicine: A Rationale and Pragmatic Approach**<br>*Daniel Gottlieb, MD, MPH* |
| 2:45-3:00pm | **Panel Discussion** |
| 3:00-3:15pm | **Refreshment Break** |
| 3:15-5:00pm | **Challenges in the Practice of Sleep Medicine**<br>**Moderator:** *Peter Gay, MD* |
| 3:15-3:45pm | **Sleep Labs are Obsolete for Perioperative Assessment of Sleep-Disordered Breathing: Pro**<br>*Lawrence Epstein, MD* |
| 3:45-4:15pm | **Sleep Labs are Obsolete for Perioperative Assessment of Sleep-Disordered Breathing: Con**<br>*Susheel Patil, MD, PhD* |
| 4:15-4:45pm | **Postoperative Monitoring for Patients with Sleep Apnea: The Good, the Bad and the Useless**<br>*Satya Krishna Ramachandran, MD, MBBS* |
| 4:45-5:00pm | **Panel Discussion** |
| 5:00-6:00pm | **Welcome Reception** |
| 6:00-8:00pm | **VIP Speaker Dinner** |
| 6:00-6:30pm | **Welcome and Introductions**<br>*Girish P. Joshi, MBBS, MD, FFARCSI* |
| 6:30-7:15pm | **Novel Ways of Diagnosing Sleep-Disordered Breathing**<br>*Koby Sheffy, PhD* |

## FRIDAY, OCTOBER 20, 2017

| | |
|---|---|
| 7:00-7:30am | **Continental Breakfast and Registration** |
| 7:30-7:55am | **Annual General Meeting**<br>*Girish P. Joshi, MBBS, MD, FFARCSI* |

## FRIDAY, OCTOBER 20, 2017 *(continued)*

| | |
|---|---|
| 8:00-9:45am | **Keynote Speakers and Special Topics**<br>**Moderator:** *Babak Mokhlesi, MD, MSc* |
| 8:00-8:05am | **Welcome – Overview** |
| 8:05-8:50am | **KEYNOTE: The Opioid Epidemic, Chronic Pain Syndromes and the Patient with Sleep-Disordered Breathing**<br>*Chad Brummett, MD* |
| 8:50-9:35am | **KEYNOTE: Traditional and Novel Ways to Monitor Patients in the Post-Operative Period**<br>*Dean Hess, PhD, RRT* |
| 9:35-9:45am | **Panel Discussion** |
| 9:45-10:30am | **Refreshment Break with Poster Viewing & Exhibits** |
| 10:30-12:15pm | **Sleep Apnea and Challenges in Pain Management**<br>**Moderator:** *Girish P. Joshi, MBBS, MD, FFARCSI* |
| 10:30-11:00am | **Pain, Opioid Analgesia, and the Patient with Obstructive Sleep Apnea**<br>*Anthony Doufas, MD, PhD* |
| 11:00-11:30am | **Postoperative Delirium and Sleep Apnea**<br>*Sakura Kinjo, MD* |
| 11:30-12:00pm | **Hypercapnic Respiratory Failure in the Early Post-Operative Period**<br>*Toby Weingarten, MD* |
| 12:00-12:15pm | **Panel Discussion** |
| 12:15-1:15pm | **Awards Presentation Luncheon & Poster Viewing**<br>**Moderators:** *Malin Jonsson Fagerlund, MD, PhD & Toby Weingarten, MD* |
| 12:15-1:00pm | **1st, 2nd & 3rd Place Abstract Award Presentations** |
| 1:00-1:15pm | **2016 Research Grant Recipient Presentation**<br>*Vidya Raman, MD* |
| 1:15-2:45pm | **Perioperative Sleep Medicine in the Era of Early Recovery After Surgery Programs**<br>**Moderator:** *Michael Pilla, MD* |

# SCHEDULE OF EVENTS

## FRIDAY, OCTOBER 20, 2017 *(continued)*

| | |
|---|---|
| 1:15-1:35pm | **Sleep-Disordered Breathing Influences Early Postoperative Recovery: Pro** *Ellen Soffin, MD, PhD* |
| 1:35-1:55pm | **Sleep-Disordered Breathing Influences Early Postoperative Recovery: Con** *Meltem Yilmaz, MD* |
| 1:55-2:25pm | **Legal Aspects of Perioperative Care of the Patient with Sleep Apnea** *Gene Hong, MD, JD* |
| 2:25-2:45pm | **Panel Discussion** |
| 2:45-3:20pm | **Refreshment Break with Poster Viewing & Exhibits** |
| 3:20-5:00pm | **Report of the SASM Guidelines Committee** **Moderator:** *Frances Chung, MBBS, FRCPC* |

| | |
|---|---|
| 3:20-3:45pm | **Perioperative Management of the Patient with Narcolepsy** *Dennis Auckley, MD* |
| 3:45-4:05pm | **Intraoperative Management of the Patient with Sleep Apnea: Airway Management** *Mahesh Nagappa, MD* |
| 4:05-4:30pm | **Intraoperative Mangement of the Patient with Sleep Apnea: Drug Responses** *Jean Wong, MD, FRCPC* |
| 4:30-4:45pm | **Intraoperative Management of the Patient with Sleep Apnea: Anesthesia Techniques** *Crispiana Cozowicz, MD* |
| 4:45-5:00pm | **Panel Discussion** |
| 5:00pm | **Closing Remarks & Giveaway** *Stavros Memtsoudis, MD, PhD* |

# IMPORTANT!

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To obtain your Continuing Medical Education (CME) certificate, go to SASM.CmeCertificateOnline.com. Click on the "SASM 7th Annual Meeting" link, complete the survey and print your certificate. Questions? Email Certificate@AmedcoEmail.com

# ABSTRACT AWARD WINNERS

## FIRST PLACE AWARD

**Abstract:** Continuous Positive Pressure Therapy Improves Symptoms of Depression in Elderly Patients with Obstructive Sleep Apnea: A Systematic Review and Meta-analysis of 11 RCTs

**Co Authors:** Talha Mubashir MD, Jayadeep Patra PhD, Amelia Maynard BSc. Candidate, Jean Wong MD, Frances Chung MBBS, Dept. of Anesthesiology, Toronto Western Hospital, University Health Network, University of Toronto

## SECOND PLACE AWARD

**Abstract:** The Perioperative Impact of Sleep Apnea in a High-Volume Specialty Practice with Focus on Regional Anesthesia

**Co Authors:** Lukas Pichler, MD, Department of Anesthesiology, Hospital for Special Surgery, Weill Cornell Medical College New York, NY, USA, Sarah M. Weinstein BA, Department of Anesthesiology, Hospital for Special Surgery, Weill Cornell Medical College New York, NY, USA, Crispiana Cozowicz MD, Department of Anesthesiology, Hospital for Special Surgery, Weill Cornell Medical College New York, NY, USA, Jashvant Poeran MD PhD, Department of Population Health Science and Policy, Icahn School of Medicine at Mount Sinai, Institute for Healthcare Delivery Science, New York, NY, USA, Stavros G. Memtsoudis MD PhD, Department of Anesthesiology, Hospital for Special Surgery, Weill Cornell Medical College New York, NY, USA

## THIRD PLACE AWARD

**Abstract:** Multimodal Analgesia and Opioid Prescription Levels in Sleep Apnea Patients Undergoing Total Hip and Knee Arthroplasties - A Population Based Study

**Co Authors:** Crispiana Cozowicz, MD, Department of Anesthesiology, Hospital for Special Surgery, Weill Cornell Medical College New York, NY, USA, Nicole Zubizarreta MPH, Department of Population Health Science and Policy, Icahn School of Medicine at Mount Sinai, Institute for Healthcare Delivery Science, New York, NY, USA, Lukas Pichler MD, Department of Anesthesiology, Hospital for Special Surgery, Weill Cornell Medical College New York, NY, USA, Jashvant Poeran MD PhD, Department of Population Health Science and Policy, Icahn School of Medicine at Mount Sinai, Institute for Healthcare Delivery Science, New York, NY, USA, Stavros G. Memtsoudis MD PhD, Department of Anesthesiology, Hospital for Special Surgery, Weill Cornell Medical College New York, NY, USA

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# ABSTRACT TABLE OF CONTENTS

\* = First Place Award Winner, ** = Second Place Award Winner, *** = Third Place Award Winner

## Save the Date

## SASM

### SASM 8th Annual Meeting
### October 11–12, 2018
### San Francisco, CA

# Death or Near-death in Patients with Obstructive Sleep Apnea: A Compendium of Case Reports

**Presenting Author:** Yamini Subramani, MD, Western University, London, Ontario
**Co-Authors:** Mahesh Nagappa, MD, Western University, London, Ontario, Jean Wong, FRCPC, University Health Network, Toronto, Ontario, Frances Chung, FRCPC, University Health Network, Toronto, Ontario

**Background:** Obstructive sleep apnea (OSA) is highly prevalent in the surgical population, with an increased risk of perioperative complications. The care of surgical patients with OSA is often fraught with safety and liability concerns. The effects of anesthetics, sedatives and narcotics on ventilatory responsiveness, arousal mechanisms and the upper airway muscle tone may potentially aggravate OSA in the postoperative period leading to life threatening hypoxia and hypercapnia. Recent closed malpractice claims of 12 surgical patients with OSA found dead in bed were reported.[1] Identifying risk factors for death or near-death in OSA patients constitutes a significant step in advancing perioperative patient safety. The objective of this report is to identify the perioperative pattern of death and near-death in OSA patients by reviewing the medical literature of the case reports, case series and medico-legal reports.

**Methods:** Case reports, case series and medico-legal reports from 1946 to June 2016 were screened to identify reports of life threatening complications and deaths in OSA patients in the perioperative period. Cases were categorized by outcomes: death, anoxic brain injury, critical respiratory events and other life threatening complications attributable to OSA. All the critical perioperative outcomes associated with OSA in terms of timing and location of events, opioid/sedative administration, OSA severity and treatment were summarized using either frequency or percentage statistics.

**Results:** The literature search yielded 935 case reports/case series reports and 73 medico-legal reports. After screening, only reports of death and near-death associated with OSA patients undergoing surgery were included. In total, 15 case reports and 2 medico-legal reports were included in our analysis. A total of 60 OSA patients suffered death or near death. Overall, there were 26 deaths, 17 anoxic brain damage, 12 critical respiratory events and 5 other life threatening complications including 2 resuscitated cardiac arrests and 3 heart blocks. Seventeen percent of OSA patients were undiagnosed before surgery. Details of CPAP therapy was available for twenty-nine patients and 34% were on preoperative CPAP. Only 30% of patients on preoperative CPAP utilized their CPAP postoperatively. Morbid obesity was associated with 8 deaths, 5 anoxic brain damage and 4 life threatening critical respiratory events. Seventy-five percent of the OSA patients with severe life threatening complications received opioids. Importantly, eighty-one percent received relatively small doses of opioids. Death or near-death occurred regardless of the route of administration. Eighty percent occurred in the first 24h and 67% in the general hospital floor (Table 1).

**Conclusion:** Surgical patients with OSA are at a high risk of death and near-death, especially in first 24h. Preoperative and postoperative usage of CPAP is suboptimal. This upholds the need to educate health care professionals and patients on the benefits of CPAP therapy. The majority of death or near-death occurred in the surgical floor, emphasizing the need for continuous monitoring to avoid failure to rescue.

**References:**
1.      Benumof JL. Can J Anaesth 2016;63:3–7.

**Table 1.  Summary of characteristics of OSA patients with death or near-death**

| | |
|---|---|
| Age, sex, body habitus Mean $\pm$ SD | 60 patients [62% males (49 $\pm$ 9 y), 38% females (46 $\pm$ 8 y)]; overall BMI: 42 $\pm$ 13 kg/m$^2$ |
| Outcomes reported (n=60) | 26 deaths, 17 anoxic brain injury, 12 CRE, 5 other serious complications (2 cardiac arrest: resuscitated, 3 heart block) |
| AHI data (events/h) (n=4) | Mean preoperative AHI 30: 2 CRE, 1 death Postoperative AHI  81 : 1 CRE |
| CPAP use (n=50) | OSA diagnosed preoperatively: 50 CPAP treatment: 10 Did not receive CPAP/treatment or information NA: 40 |
| Timing of deaths, near deaths and CRE | 92% (45/49) - 1st 72 h, 80% (39/49) - 1st 24 h, 12% (6/49) – 24 -72 h, 8% (4/49) - >72 h, Cx timing: NA (n=11) |
| Location of deaths, near deaths and CRE (n=60) | OR: 13% (8/60) PACU: 18% (11/60) Floor: 67% (40/60) |
| Opioid use: Opioids given: 45 Opioids not given: 15 | 75%(n=45) OSA patients with death or near-death received opioids, 81%(n=13) received relatively small doses of opioids |
| Route of opioid administration | IV opioids: 17 IM opioids: 3 Epidural opioids: 4 IV PCA opioids: 8 No opioid: 15 Route of administration NA: 10 |

BMI - Body mass index; Cx - Complications; NA – Not available; OSA – Obstructive sleep apnea; CRE – Critical respiratory events; AHI – Apnea hypopnea index; CPAP – Continuous positive airway pressure; D – Death; PACU –Post anaesthesia care unit; y=years; SD – Standard deviation; n – Number; h – Hours; y - Years

# Post-Operative Analgesia Requirements in 1,009 Consecutive Patients Receiving Opioid-Free Anesthesia

**Presenting Author:** David Samuels, MD, TEAMHealth Anesthesia
**Co-Authors:** Enrico Camporesi, MD, TEAMHeath Anesthesia Research Institute & University of South Florida, Giorgio Melloni, PhD, Harvard Medical School, Prachiti Dalvi, MS, TEAMHealth Anesthesia Research Institute, Devanand Mangar, MD, TEAMHealth Anesthesia & University of South Florida

**Introduction:** Opioids produce many undesirable side effects such as respiratory depression, sedation, nausea/vomiting, constipation, and ileus. Short-acting opioid used during anesthesia may lead to acute opioid-induced tolerance and hyperalgesia [1]. Furthermore, opioid addiction and overdosing are recognized as national problems. Most overdose deaths result from access to prescription opioids [2]. Multimodal opioid-sparing analgesia has become an alternative to managing post-surgical pain in the last two decades [3]. One of the anesthesiologists in our practice (DS) provided anesthesia services to 19 surgeons for 1,009 consecutive patients without the use of opioids for a variety of procedures.

**Materials & Methods:** We were granted IRB-approval from the University of South Florida's IRB to retrospectively review surgical cases of patients with a single anesthesiologist at an outpatient surgery center. Surgical procedures included direct laryngoscopy, complex facial plastics, skin lesions, middle ear procedure, nasal/sinus procedures, and tonsillectomy and adenoidectomy

*Opioid-Free Intraoperative Anesthesia Protocol:* All adult patients received 1000mg of P.O. acetaminophen and pediatric patients receive 10-15mg/kg per rectum. If patients had obstructive sleep apnea, they received IV acetaminophen. All patients received magnesium 60mg/kg while patients over the age of 65 or having kidney disease received 30mg/kg. Ketamine (0.3mg/kg) and lidocaine (1.5mg/kg) was also given. Adult patients received 30mg Ketorolac (15mg if the patient is over 65 years of age) if the surgeon allowed it. Middle ear surgery patients received gabapentin 300mg P.O. All patients received Deacadron 10mg (peds 0.1mg/kg) and Zofran 4mg. All patients received supplemental Sevoflurane.

*PACU Management:* Patients were given oral hydrocodone or oxycodone for complaints of pain in the PACU and intravenous lidocaine/magnesium for complaints of intractable, unremitting pain in the PACU. If patients complained of nausea they were given 4mg Zofran. Patients received Phenergan if nausea persisted or vomiting ensued.

Statistical analysis involved logarithmic regressions between different procedural groups.

**Results:** Patients and surgeons declared satisfaction with this anesthesia protocol and post-operative pain management was well-tolerated. Only 36% of patients requested oral opioid medications in the PACU despite having received opioid-free anesthesia, with certain procedures such as complex facial plastics and nasal/sinus surgeries with longer case lengths requiring notably more pain medications than other surgical procedures. Patients in these two procedural groups also required more nausea medication (Table).

**Discussion:** The study shows that a general anesthetic can be provided safely without opioids, suggesting that multimodal analgesics are acting preemptively. Future prospective studies can elucidate which medications utilized during the OFA regimen are essential. Patients can also be monitored post-operatively to understand opioid needs for at-home pain. Our surgeons agreed

to prescribe on average only 15 PO opioid tablets post-operatively for each patient, in lieu of the usual 50, thus decreasing unused pills leftover for possible diversion.

**Conclusion:** In conclusion, safe anesthesia for multiple procedures varying in duration from an hour to several hours while using minimal opioids is possible.

**References:**

[1]     Angst, C. Anesthesiology 2006; 104:570-87
[2]     Rudd et al. CDC MMWR 2016; 64(50);1378-82
[3]     Kehlet, D. Anesth Analg 1993; 77:1048-1056

Table: Patient Outcomes for 1009 Consecutive Patients Receiving Opioid-Free Anesthesia (**: $p < .01$, *$p$: $< 0.05$ for comparisons between different procedures)

| Procedures | Number of Patients | Minutes in PACU | % Oral Opioids Request in PACU | % Nausea in PACU | % Persistent Nausea |
|---|---|---|---|---|---|
| Direct Laryngoscopy | 62 | 53 ± 18 | 19.35% | 4.84% | 0.00% |
| Facial Plastics | 109 | 90 ± 32 | 52.29%** | 25.69%** | 8.26%* |
| Lesion, Skin | 76 | 48 ± 16 | 17.11% | 3.95% | 0.00% |
| Middle Ear | 247 | 55 ± 22 | 14.57% | 7.69% | 1.21% |
| Nasal/Sinus | 318 | 74 ± 30 | 53.46%** | 12.26%* | 0.31% |
| Tonsillectomy & Adenoidectomy | 197 | 55 ± 18 | 38.07% | 7.11% | 1.02% |
| Total | 1009 | 64 | 35.98% | 10.51% | 1.49% |

# Feasibility and Cost of Drug-Induced Sedation Endoscopy (DISE) in the Bronchoscopy Suite

**Presenting Author:** Enrico Camporesi, MD, TEAMHealth Anesthesia Research Institute & University of South Florida
**Co-Authors:** Prachiti Dalvi, MS, TEAMHealth Anesthesia Research Institute, Karel Calero, MD, University of South Florida, Tapan Padhya, MD, University of South Florida, Devanand Mangar, MD, TEAMHealth Anesthesia & University of South Florida

**Introduction:** Patients with obstructive sleep apnea (OSA) may experience difficulty tolerating positive airway pressure (PAP) therapy. Drug Induced Sedation Endoscopy (DISE) assesses airway characteristics while the patient is sedated with general anesthesia, simulating sleep, and can help guide alternative interventions for OSA. Since DISE procedures are performed in the operating room, they are expensive and their availability is limited by the surgeon's busy schedule. Performing DISE in the bronchoscopy suite may reduce costs and improve access to care while maintaining a low risk for complications.

**Methods:** Following training by an ENT physician, a sleep-boarded pulmonologist performed DISE in the bronchoscopy suite. Patients with OSA and difficulty tolerating PAP therapy were evaluated for alternative interventions via DISE. A propofol infusion was administered by an anesthesiologist trained on performing DISE and sedation level was tracked via Bispectral Index$^{TM}$ for a target level of 60-75%. Videos of the DISE were recorded for multidisciplinary conference review with ENT and to track patient outcomes following interventions. Baseline polysomnography prior to DISE was reviewed to classify severity of OSA. Complication rates were tracked. Facility costs of DISE in the bronchoscopy suite were compared to those of the operating room.

**Results:** The sleep-trained pulmonologist performed 21 DISE procedures in the bronchoscopy suite over a period of ten months. Review of polysomnography prior to DISE demonstrated an average AHI of 34.3+/-15.9 and an average SpO2 nadir 78 +/- 8.3%. No complications were observed during DISE. The facility fee for performing DISE procedures in the operating room was on average $1700 more than the facility fee for performing DISE in the bronchoscopy suite while charges for anesthesia and equipment used were the same (Table 1: values are Mean ± 1 SD). The added cost in the OR is directly attributed to the higher cost structure of OR and PACU space and personnel.

**Conclusion:** Based on these findings, performance of DISE in the bronchoscopy suite appears feasible, safe and cost effective. It is performed by a sleep trained pulmonologist and has the potential to improve access to care and may help identify successful alternative treatments for patients with PAP intolerance. Further studies are needed to identify the training necessary for pulmonary-based sleep specialists to become proficient in the procedure.

**References:**
[1]    Vanderveken OM, et al. J Clin Sleep Med. 2013; 9(5):433-438.
[2]    Strollo PJ, et al. NEJM. 2014; 370:139-149.
[3]    Hohenhorst W, et al. Oper Tech Otolaryngol. 2012;23:11-18.

**Table 1.** Comparison of DISE in Bronchoscopy Suite and Operating Room.

| | | | |
|---|---|---|---|
| • Same anesthesia team in Bronchoscopy Suite and Operating Room. | | | |
| • Same equipment used in Bronchoscopy Suite and Operating room. | | | |
| **Characteristics of Procedure** | | | |
| | **Length of Procedure (min)** | **Recovery Time (min)** | **Average Cost (USD)** |
| Bronchoscopy Suite | $34 \pm 12$ | $78 \pm 37$ | $3000 |
| Operating Room | $35 \pm 12$ | $75 \pm 5$ | $4700 |

# Flumazenil Not With Pre-, But Co-administered Bicuculline Caused Marked Excitation in Diazepam-induced Hypoglossal Nerve Inhibition in Anesthetized Rabbits

**Presenting Author:** Shingo Hijikata, MD, Junior Resident, Kumagaya General Hospital, Japan
**Co-Authors:**
1. Shin-Chan (Shinichi) Nakamura, MD, PhD, Kumagaya General Hospital and Saitama Medical University, Saitama, Japan
2. Masahiko Suzuki, PharD, Saitama Medical University, Saitama, Japan
3. Shingo Hijikata, MD, Junior Resident, Kumagaya General Hospital, Japan
4. Masaaki Nishida, MD, PhD, Children's Hospital of Michigan, Detroit, MI, USA and Hanyu General Hospital, Saitama, Japan
5. Akira Kitamura, MD, PhD, SMU International Medical Center, Saitama, Japan

**Background:** During sedation with Benzodiazepines (Bz) often occurs respiratory depression such as upper airway obstruction and insufficient ventilation. These unfavorable side effects are thought coming out of that Bz inhibits the hypoglossal nerve activity (HGA), which regulates upper airway patency, via Bz-GABA$_A$ receptor complex related to respiratory control mechanisms in the CNS.

The purpose of this study is to investigate how a specific Bz antagonist flumazenil (FUL) and bicuculline (BIC), a competitive GABA$_A$ antagonist, affect the diazepam (Dz)-induced hypoglossal nerve inhibition (Dz-I) with or without their combination. Methods: The studies were approved by the Saitama Medical University Animal Care Committee. Studies were carried out in adult rabbits (n=24) which were vagotomized, paralyzed and artificial ventilated with 50% $N_2O$, 50% $O_2$ and 0.5% sevoflurane for basal anesthesia.

This experiment is composed following three steps. The first step induced Dz-I by a total dose of 2.0 mg/kg Dz. The second step was injections of antagonists. Based on the tested antagonists, we divided the rabbits into four groups: Group one, no antagonists for sham treatment; group two, FLU; group three, BIC; and group four, a combination of FLU with BIC. The final step was the injection of FLU for all groups.

We measured the root mean square (RMS) in integrated hypoglossal neurogram for data analysis. Statistical analysis was performed by ANOVA with Dennett's test; $p < 0.01$ (indicated by *) was considered significant.

A used 0.2 mg/kg of FLU had an ability to antagonize the Dz-I induced by a total dose of 10 mg/kg Dz in our trial experiments. A dose of BIC, 0.1 mg/kg, was chosen to block GABA-mediated respiratory inhibitions effectively but remained in sub-convulsive range.

**Results:** Dz-I was characterized by a rough 40-50 percent decrease in HGA from the control level. Sham treatment (Fig.-1) showed that Dz-I lasted stably until FLU administration, when antagonism occurred. FLU antagonized Dz-I promptly with a short duration of antagonism and induced neither cumulation, potentiation nor tachyphylaxis in the subsequent FLU induced responses (Fig.-2). After BIC injection, there were no significant changes in Dz-I like as the results in the sham treatment, but except for a transient trivial excitation appeared following FLU injection (Fig.-3). On the other hand,

a combination of FLU with co-administered BIC caused marked excitation going up to around 270 percent of control (Fig.-4).

**Conclusion:** Under the experimental condition the diazepam-induced hypoglossal nerve inhibition (Dz-I) was antagonized by flumazenil (FLU), a specific antagonist of benzodiazepine (Bz) receptor sites, but not reversed by $GABA_A$ antagonism of a competitive antagonist bicuculline (BIC), which makes it unlikely that it was mediated by the elaboration of the Bz-$GABA_A$ receptor complex system or any interrelated constituents of that; However the ability of flumazenil to induce hypoglossal nerve potentiation, i.e., marked excitation beyond its expected effect of antagonism, appears to be related to simultaneous coexistence with $GABA_A$ antagonism by bicuculline. The physiologic role and detailed mechanism in shaping the hypoglossal nerve excitation remain to be established.



Fig.-1: Sham Treatment

Fig.-3: Bicuculline

Fig.-2: Flumazenil

Fig.-4: Flumazenil with Bicuculline
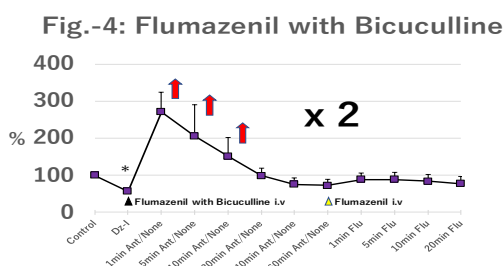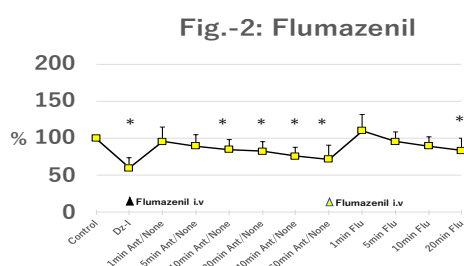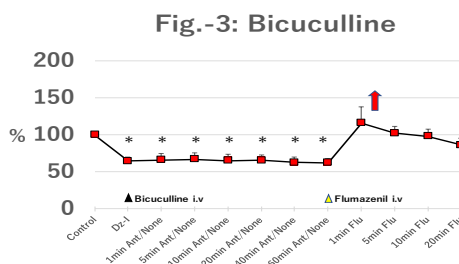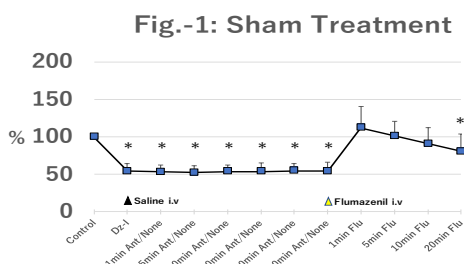
* =P<0.01 vs. Control  Mean + S.D.  ⬆ : Excitation: beyond 10 % from control

# Measuring Pulse Oximetry in the PACU: Is It Really the Best Choice to Assess for Respiratory Compromise?

**Author:** Carla R. Jungquist, PhD, ANP-BC, FAAN, University at Buffalo, Buffalo NY
**Co-Author:** Cheryl Spulecki, DNAP, CRNA, University at Buffalo, Buffalo, NY

**Background:** Opioid analgesics are commonly administered to hospitalized patients to treat pain, but these drugs pose risks for serious adverse events such as unintended advancing sedation, respiratory depression, and even death. Hospitalized patients who experience opioid-related adverse events typically have poorer clinical outcomes. For example, postsurgical patients receiving parenteral or oral opioids experiencing opioid-related adverse drug events have 55% longer hospital stays, 47% higher costs associated with their care, a 36% increased risk of 30-day readmission, and a 3.4 times higher risk of inpatient mortality compared to those having adverse drug events from opioids(1). In a study of over 1.14 million nonsurgical admissions across 286 hospitals nation-wide, about 50% of patients received opioid medications and 0.60% (6 out of every 1000 patients) experienced serious adverse events (defined by naloxone exposure or an opioid-related adverse drug event diagnosis code) including respiratory depression(2). It is time for nurses to better identifying patients at risk, and then institute opioid-sparing pain management or better monitoring techniques. Adverse events secondary to Opioid Induced Respiratory Depression (OIRD) are preventable.

**General Aim:** To explore which of three types of electronic monitoring devices (pulse oximetry, capnography, or a device that measures minute ventilation) were more feasible and effective at detecting OIRD.

**Materials and Methods:** A study was performed in the PACU at a community hospital in Buffalo NY. Nurse anesthesia students recruited 60 patients in the pre-operative admissions department. Forty-nine of the 60 patients wore three types of electronic monitoring devices while they were recovering from back, neck, hip or knee surgery in the PACU.

**Results:** The study found that in the setting of supplemental oxygen, pulse oximetry is not a reliable and effective method to assess respiratory compromise. Twenty-four of the 49 patients exhibited sustained signs of OIRD within minutes of receiving an opioid while in the PACU. While the pulse oximetry readings didn't change, end Tidal $CO_2$ levels increased and Minute Ventilation decreased, representing hypoventilation. A tool commonly used to screen patients for OIRD is the STOP-BANG questionnaire. In this study, the STOP-BANG questionnaire was not predictive of the patients who exhibited signs of OIRD.

**Discussion/conclusions:** Electronic monitoring devices are currently used as a tool to assess respiratory compromise using thresholds to distinguish compromise. The investigators of this study are proposing a paradigm shift for nurses to use electronic monitoring devices to expose the patient at risk of adverse events from OIRD using trend monitoring that entails comparing the patients current reading with pre-opioid readings. Once the patient is identified, opioid sparing multimodal pain management strategies can be ordered, or the patient can be continuously monitored using the appropriate electronic device once transferred to the general surgical unit. Choosing the appropriate electronic monitoring device is key to preventing adverse events. In the setting of supplemental oxygen use, capnography or minute ventilation will be more sensitive in detection of respiratory compromise.

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# Continuous Positive Pressure Therapy Improves Symptoms of Depression in Elderly Patients with Obstructive Sleep Apnea: A Systematic Review and Meta-analysis of 11 RCTs

**Presenting Author:** Talha Mubashir MD, Dept. of Anesthesiology, Toronto Western Hospital, University Health Network, University of Toronto
**Co-Authors:** Jayadeep Patra PhD, Amelia Maynard BSc. Candidate, Jean Wong MD, Frances Chung MBBS, Dept. of Anesthesiology, Toronto Western Hospital, University Health Network, University of Toronto

**Background:** Depression and obstructive sleep apnea (OSA) are both frequently associated with sleep disturbances, fatigue and irritability.[1] Differentiating between these two disorders can be quite difficult due to their overlapping symptomatic profiles and risk factors. Moreover, concomitant cardiovascular and metabolic diseases accompanying the elderly population have been shown to influence these diseases negatively.[2] Nevertheless, several studies have linked an association between OSA and depression in the elderly. Given the increasing prevalence and associated functional impact of OSA on the elderly, early diagnoses and treatment implementation is important. The objective of this study is to determine if treatment with CPAP improves symptoms of depression in elderly patients with OSA.

**Methods:** Medline, EMBASE and the Cochrane Library were searched up to May 2017 for randomized controlled trials (RCTs) comparing the effect of CPAP or an inactive control treatment on depressive symptoms measured using validated depression scales in OSA. Two authors independently extracted the study characteristics, quality and bias assessment. Inclusion criteria were: (1) RCTs with a mean age of participants' ≥ 60 years; (2) a diagnosis of sleep apnea based on the results of a portable or laboratory polysomnography. A diagnosis of depression at baseline was not required based on established cutoff values of depression scales; (3) OSA was clearly defined as apnea hypopnea index (AHI), respiratory disturbance index (RDI), or oxygen desaturation index (ODI) of ≥ 5 events/hr; (4) an intervention of CPAP therapy vs standard therapy or sham CPAP was utilized; (5) validates scales used to measure subjective or objective depression and/or depressive symptoms; (6) publications in any language. Ratio of Mean (RoM) was used as a standardized measure of effect size. Random effect meta-analysis was used to pool effects sizes.

**Results:** For the meta-analysis, 3,052 studies were identified and 11 RCTs with 888 patients were included. The mean age of participants ranged from 61.0 to 77.4 years with a mean AHI of 28.1-50.4 events/hr. A random effects meta-analysis of 11 identified trials showed a significant improvement in depressive symptoms with CPAP treatment compared to controls: pooled ratio of mean (RoM) = 1.41 (95% CI: 1.09-1.82). There was a substantial heterogeneity between the trials (Q statistic 73.1, $p < 0.001$; $I^2$ = 86%, 95% CI: 77%, 92%). A stratified analysis and meta-regression was conducted. CPAP treatment resulted in significantly greater improvement in depressive symptoms in patients without comorbidities vs patients with stroke (meta-regression, p=0.038). The treatment effect of CPAP was modified by the OSA severity, with a greater improvement observed in patients with moderate OSA compared to patients with severe OSA (meta-regression, p = 0.016). The treatment effect was significantly lower when SF (short form)-36 mental component summary (MCS) was used to measure depressive symptoms vs other depression scales (meta-regression, p=0.08).

**Conclusions:** CPAP was found to be effective in improving symptoms of depression in elderly patients with OSA with the greatest benefits in older populations without comorbidities and those with moderate OSA.

**References**

1) Harris M et al. *Sleep Med Rev.* 2009;13:437-444.
2) Jordan A et al. *Lancet.* 2014;383:736-747.

**Table 1.  Provides RCTs characteristics on the effect of CPAP on depression in elderly patients with OSA.**

| RCT (Type) | Age (Mean ± SD) | Sample (E/C) | Male (%) | BMI (kg/m², mean ± SD) | AHI Baseline/Residual (events /h, mean ± SD)" | ODI Baseline‡ (events/h, mean ± SD) | Study Duration (weeks) | Comorbidity | Intervention | Control | Mean adherence in Tx / Control arm (h/Night) | Depression scale(s) (Mean score) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aaronson et al. 2016 (P) | 61.1 ± 8.2 | 20/16 | 60 | 27.1 ± 6.4 | 33.7 ± 12.8 vs 11.0 ± 11.0 | 34.2 ± 16.4 | 4 | Stroke | CPAP | Standard care | 2.5/NA | HADS-D (4.8 ± 3.2) |
| Cooke et al. 2009 (P) | 75.7 ± 5.9 | 5/5 | 70 | 25.9 ± 3.1 | 28.3 ± 15.8* vs 1.6 ± 2.3 | NR | 13.3 mo | AD | CPAP | Standard care | NR | CSD (5.1 ± 3.9)* |
| Dalmases et al. 2015 (P) | 71.3 ± 5.5 | 17/16 | 69.8 | 32.8 ± 3.9 | 55.3 ± 16.8 vs 7.2 ± 6.7 | 41.8 (28.4-61.0)‡ | 12 | none | CPAP | Standard care | 6/NA | HADS-D (3.6 ± 2.9) |
| Egea et al. 2008 (P) | 63.5 ± 1.2 | 28/32 | 93.5 | 31.7 ± 2.4 | 42 ± 27.4 vs 10.8 ± 11.4 | NR | 12 | CHF | CPAP | Sham CPAP | NR | SF-36-MCS (48.8 ± 2.3) |
| Hsu et al. 2006 (P) | 73.8 ± 8.1 | 15/15 | 66.8 | 26.8 (21.9-28.5)‡ | 45.8 ± 16.2 vs NR | 15.8 (8.1-22.7)‡ | 12 to 24 | Stroke | CPAP | Standard care | 1.5/NA | HADS-D [5 (2-9)]‡, SF-36-MCS[49.8 (39-60.2)]‡ |
| Martinez-Garcia et al. 2015 (P) | 75.5 ± 3.9 | 115/109 | 68.4 | 32.9 ± 6.3 | 50.3 ± 14.5 vs 3.9 ± 7.4 | 49.6 ± 20.2 | 12 | none | CPAP | Standard care | 4.9/NA | HADS-D (6.9 ± 4.5) |

| Study | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| McMillan et al. 2014 (P) | 71.1 ± 4.6 | 140/138 | 82.5 | 33.7 ± 6.1 | NR | 28.7 ± 19.1 | 12 mo | none | CPAP | Standard care | 2.3/NA | HADS-D (4.5 ± 2.8) |
| Parra et al. 2011 (P) | 64.7 ± 9.2 | 57/69 | 70.6 | 30.2 ± 4.6 | 38.4 ± 13.7 vs NR | NR | 24 mo | Stroke | CPAP | Standard care | 5.3/NA | SF-36-MCS (47.1 ± 13.3) |
| Ryan et al. 2011 (P) | 61.7 ± 11.5 | 22/22 | 79.5 | 28.8 ± 5.3 | 35.9 ± 17.2 vs 7.6 ± 8.5 | NR | 4 | Stroke | CPAP | Standard care | 4.9/NA | BDI (7.0 ± 7.4) |
| Sandberg et al. 2001 (P) | 77.4 ± 7.1 | 31/28 | 45.7 | 24.5 ± 4.1 | 30.5 ± 12 vs NR | NR | 4 | Stroke | CPAP | Standard care | 4.1/NA | MADRS (21 ± 10.4) |
| Smith et al. 2007 (X) | 61 ± 8 | 26 | 88.4 | 31 ± 4 | 36 ± 23 vs NR | 22 ± 26 | 12 | CHF | CPAP | Sham CPAP | 3.5/3.3 | SF-36-MCS (49 ± 12) |

*Baseline data taken from Ancoli-Israel et al. (2008), a former study to Cooke et al. (2009); ɫValues are median (interquartile range); ‡no study reported residual ODI; RCTs: P-Parallel, X-cross-over; NA: not applicable (sham CPAP not utilized as a control); NR: not reported or unclear; E-experimental/C-control; Standard care varies among studies and not always defined: advice on minimizing daytime sleepiness through sleep hygiene and naps, dietary counseling, weight loss or standard stroke rehabilitation; AHI: Apnea hypopnea index; ODI: Oxygen desaturation index, events were oxygen desaturations of 3% or greater; CHF: Chronic heart failure; AD: Alzheimer's disease; CSD: Cornell scale for depression; BDI: Beck depression inventory; HADS-D: Hospital anxiety and depression scale - depression component; SF (short form)-36 MCS: All values taken correspond to the mental component summary;  MADRS: Montgomery-Åsberg Depression Rating Scale.

# Anesthetic Complications in Patients with Primary Central Sleep Apnea

**Authors:** Alexandru Alexa, MD[1], Bhargavi Gali, MD[1], Toby N. Weingarten, MD[1], Meghna P. Mansukhani, MD, FAASM[2]

[1]Department of Anesthesiology and Perioperative Medicine, Mayo Clinic, MN
[2]Center for Sleep Medicine, Mayo Clinic, MN

**Background:** Idiopathic or Primary Central Sleep Apnea (CSA) is a rare CSA syndrome, characterized by frequent central apneas which occur predominantly in non-rapid eye movement sleep associated with sleep disturbances, and/or daytime sleepiness.[1,2] Anesthetic management of patients with Primary CSA has not been described. We aimed to study the perioperative course of patients with Primary CSA undergoing anesthesia at our institution.

**Materials and Methods:** A retrospective review was conducted of medical records of patients diagnosed at Mayo Clinic Rochester with Primary CSA (per current diagnostic criteria), prescribed appropriate home positive airway pressure (PAP) therapy and who were administered anesthesia between 2009 and 2017.

**Results:** Eleven patients (10 males, 1 female, mean age at diagnosis 70±13 years) underwent 49 procedures requiring anesthetic management (22 [45%] general anesthesia, 25 [51%] monitored anesthesia care, 2 [4%] regional anesthesia). The median apnea-hypopnea index was 53 [26.5, 68] episodes/hr and central apnea index was 31.5 [22.5, 41.5] episodes/hr. There was a high degree of comorbidity with 6 patients having a history of cerebrovascular disease. The intraoperative course was complicated by 19 (39%) episodes of hypoxemia and one episode of new onset atrial fibrillation with rapid ventricular response. During anesthetic recovery, five (10%) patients were deeply sedated, 4 (8%) had episodes of hypoxemia, 1 patient developed second-degree heart block with syncope, 5 (10%) had prolonged recovery (> 2 hours), 1 (2%) unplanned intensive care unit (ICU) admission for respiratory failure, 2 (4%) unexpected hospital admissions for respiratory monitoring, and 2 (4%) were readmitted within 30 days. One patient who underwent an Ivor-Lewis procedure required 6 hours of postoperative mechanical ventilation and later (postoperative day 9) developed pneumonia, which required mechanical ventilation and broad spectrum antibiotics.

**Conclusion:** In this cohort of patients with Primary CSA who received anesthesia, hypoxemia was noted frequently during the intraoperative course, and the anesthetic recovery period was notable for episodes of sedation and hypoxemic events, necessitating unplanned ICU or hospital admission in a few cases. It is unknown whether the use of PAP devices during anesthetic recovery would have reduced the rate of these observations.

**References:**
1. American Academy of Sleep Medicine. International Classification of Sleep Disorders, 3rd ed. American Academy of Sleep Medicine, Darien, IL 2014.
2. Muza RT. Central sleep apnoea-a clinical review. *Journal of Thoracic Disease.* 2015: 7(5): 930-937. Doi:10.3978/j.issn.2072-1439.2015.04.45.

**Table. Demographics and Perioperative Course of 11 Patients with Primary Central Sleep Apnea Undergoing a Total of 49 Anesthetics.**

| | Patients (n=11) |
|---|---|
| **Patient characteristics** | |
| Age at diagnosis, years | 70 ± 13 |
| Male sex | 10 (90.9%) |
| Comorbid Conditions | |
|   Neurological | |
|     Stroke | 6 (54.5%) |
|     Multiple Sclerosis | 1 (9.0%) |
|   Cardiovascular | |
|     Atrial fibrillation | 3 (27.2%) |
|     Coronary artery disease | 3 (27.2%) |
|     Abdominal aorta repair | 1 (9.0%) |
|   Diabetes Mellitus II | 4 (36.3%) |
| Polysomnography results | |
|   Apnea Hypopnea Index, episodes/hour | 53 [26.5, 68] |
|   Central Sleep Apnea, episodes/hour | 31.5 [22.5, 41.5] |
| PAP Treatment | 10 (90.9%) |
|   ASV | 7 (63.6%) |
|   VPAP | 3 (27.2%) |
| Pharmacologic Therapy | 6 (54.5%) |
|   Melatonin | 2 (18.1%) |
|   Antidepressants | 4 (36.3%) |
|   Pramipexole | 1 (9.0%) |
|   Hydroxyzine | 1 (9.0%) |
| **Surgical Characteristics** | **Surgical Procedures (N=49)** |
| Type of surgery | |
|   General | 6 (12.2%) |
|   Orthopedic | 7 (14.2%) |
|   Ophthalmologic | 8 (16.3%) |
|   Cardiac | 1 (2.0%) |
|   Urology | 13 (26.5%) |
|   Miscellaneous | 14 (28.5%) |
| Duration-minutes | 76 [42.5, 130] |
| Anesthetics | |
|   General | 22 (44.8%) |
|   MAC | 25 (51.0%) |
|   Regional | 2 (4.0%) |
| Opioid IV Morphine Equivalents | 9.5[2.5,21.75] |
| NDMD:Reversed | 12:10 |
| Intraoperative Events | |
|   Hypoxia | 19 (38.7%) |
|   SVT/Afib w/ RVR | 1 (2.0%) |
| PACU Events | |

| | |
|---|---|
| Duration, minutes | 63[37.5,90.5] |
| Duration >2 hours | 5 (10.2%) |
| RASS </= -2 | 5(10.2%) |
| Hypoxia | 4 (8.1%) |
| Unanticipated Complications | |
| Second degree heart block Mobitz II | 1 (2.0%) |
| Unexpected ICU admission (acute hypoxic respiratory failure) | 1 (2.0%) |
| Admission secondary to hypoxia | 2 (4.0%) |
| Readmissions < 30 days secondary to neurologic, cardiac or respiratory problem | 2 (4.0%) |

Hypoxia defined as Spo2 <90%.

Acute Hypoxic Respiratory Failure secondary to pulmonary edema.

Admission secondary to hypoxia and fever after flexible bronchoscopy, and also for hypoxia and Community Acquired Pneumonia after flexible bronchoscopy.

Readmission secondary to confusion, and then secondary to atypical chest pain.

# Novel Unobtrusive Fibreoptic Mat Sensor Detection of Sleep Apnea

**Presenting Author:** Edwin Seet, MD, Khoo Teck Puat Hospital, Alexandra Health System

**Co-Authors:** Ibrahim Sadek, Masters, Institute for Infocomm Research, Singapore, Jit Biswas, PhD, Singapore University of Technology and Design, Haihong Zhang, PhD, Neural and Biomedical Engineering Institute for Infocomm Research Singapore, Mounir Mokhtari, PhD, Image and Pervasive Access Laboratory Institut Mines-Télécom Singapore

**Background:** Obstructive sleep apnea (OSA) is a disorder characterised by repetitive breathing cessation or reduced inspiratory airflow due to upper airway obstruction during sleep. The gold standard diagnosis of OSA consists of an attended polysomnography. Routine preoperative diagnosis with this method is prohibitive given its requirements. Less resource-intensive methods of screening and apnea monitoring is desirable. Ballistocardiography can provide unobtrusive monitoring of physiological signals without the need for any wearable sensors.[1] We seek to investigate the utility of a novel inexpensive unobtrusive mat-based microbend fiberoptic sensor.

**Methods:** After ethics approval and informed consent, 10 patients suspected or diagnosed with OSA scheduled for drug-induced sleep endoscopy in the operating room were recruited. Peri-procedural data correlation was performed between the mat-based microbend fiberoptic sensor and existing commercially available 3-channel home sleep apnea testing device (ApneaLink-Plus, Resmed). We compared the apnea-hypopnea index obtained from the ApneaLink device to that obtained from the novel mat-based microbend fiberoptic sensor.

**Results:** Averaged across 10 patients, the system achieved a sensitivity of 66.7±17.9%, a specificity of 70.2±7.9%, an accuracy of 69.5±7.9% (Table 1), and area-under-the-curve of 70.0±8.8% for sleep apnea detection (Figure 1). Additionally, the system achieved satisfactory results for heart and respiratory rates with a mean error of 0.6±0.6 beats/minute and 0.4±0.3 breaths/minute respectively. Pearson correlation coefficient with the reference measurement device was 0.96 for heart rate, and 0.78 for respiratory rate.

**Discussion & Conclusion:** It is expected that this research will pave the way towards unobtrusive screening of OSA and detection of apnea in real time.

## References

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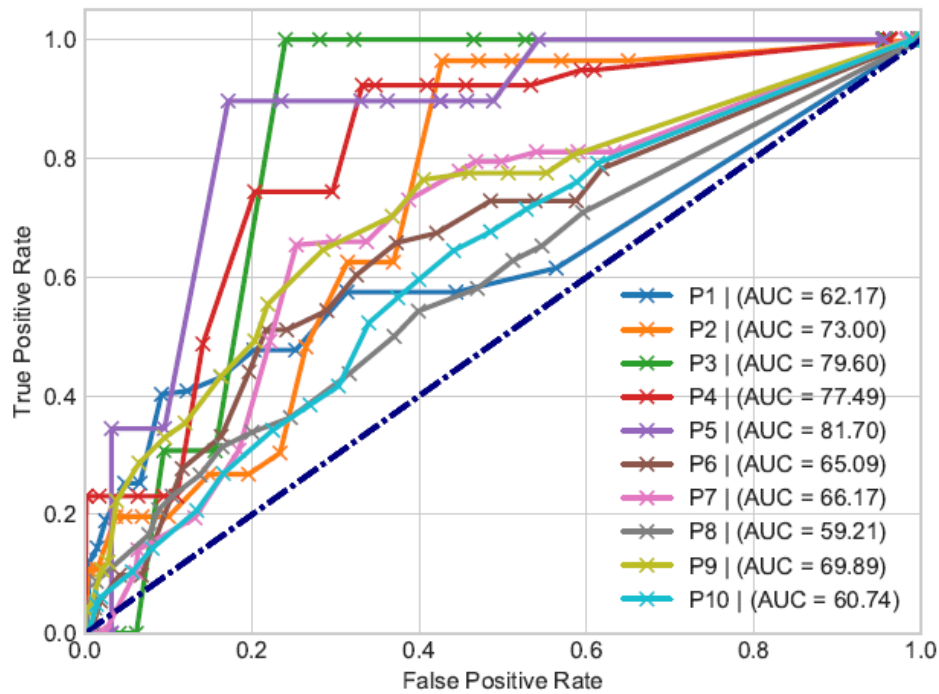
**Figure 1.** The ROC curves for all 10 patients.

**Table 1.** Sensitivity, specificity, accuracy, and the AUC of sleep apnoea detection.

|  | Sensitivity % | Specificity % | Accuracy % | AUC % |
|---|---|---|---|---|
| AHI < 5 | 52.52±14.13 | 74.36±11.66 | 73.74±10.84 | 67.2±7.99 |
| 5 ≤ AHI < 15 | 100 | 84.22 | 84.63 | 81.73 |
| 15 ≤ AHI < 30 | 73.79±12.31 | 66.81±4.04 | 67.46±4.4 | 73.42±8.4 |
| AHI ≥ 30 | 55.7±8.88 | 67.23±5.74 | 64.26±3.97 | 63.21±6.17 |
| Overall | 66.73±17.91 | 70.19±7.85 | 69.47±7.97 | 69.95±8.76 |

Results are described as mean ± standard deviation.

# Risk Factors for Postoperative Opioid Induced Respiratory Depression in Surgical Patients

**Presenting Author:** Kapil Gupta, Clinical Fellow, Department of Anesthesiology and Pain Medicine, Toronto Western Hospital, University Health Network, University of Toronto, Canada

**Co-Authors**: Arun Prasad, MBBS, Anesthesia, University Health Network, University of Toronto, Jean Wong MD, Anesthesia, University Health Network, University of Toronto, Frances Chung, MBBS, Anesthesia, University Health Network, University of Toronto

**Background:** There are many reports of opioid induced respiratory depression (OIRD) in the post-operative period resulting in morbidity and mortality [1]. However, the factors which predispose patients to increased risk of OIRD in the post-operative period are unclear. The primary objective of this systematic review is to identify the risk factors for OIRD in surgical patients in the postoperative period.

**Materials & Methods:** A literature search was performed according to PRISMA guidelines to search the following databases: MEDLINE, Embase, Cochrane Central Register of Controlled Trials and Cochrane Database of Systematic Reviews, PubMed and ClinicalTrials.Gov (up to November 7, 2016). The inclusion criteria were: (1) adult surgical patients (greater than 18 years old); (2) prescribed opioids during their hospital stay post-surgery; (3) available reports on postoperative respiratory events or adverse outcomes; and (4) published studies in English language.

**Results:** Our initial search yielded 8,663 citations. After deduplication and screening of the abstracts and titles, 121 articles were included for further review. After reading full texts and removing all case reports, 13 studies were found suitable for inclusion in this systematic review. Respiratory depression in our review is defined as respiratory rate lower than 10 /min or oxygen saturation less than 90%. The total number of surgical patients were 871,912 and the number of patients with postoperative OIRD were 4,337 with a prevalence of 0.50 % (Table). The mean age of patients with OIRD was greater than 60 years and 50-60% of patients with OIRD were females. In ten studies, OIRD was reported mostly after orthopedic surgeries. Predominantly, OIRD was reported within the first 24h after surgery, especially within the first 12h. The presence of obstructive sleep apnea, chronic obstructive pulmonary disease, cardiac disease, diabetes mellitus, hypertension, neurologic disease (stroke, dementia), renal disease, obesity, two or more co-morbidities, opioid dependence, use of patient controlled analgesia pump (especially with continuous background opioid infusion), multiple prescribers of opioids, use of two or more opioids and genetic predisposition have all been reported to be significant risk factors for OIRD. The majority of patients were deeply sedated and inadequately monitored before the occurrence of OIRD.

**Discussion:** The majority of OIRD were reported within 24h postoperatively. This may be due to the additive effect of residual anesthetic drugs and narcotics on respiratory depression. Elderly are more sensitive to the central depressant effects of opioids, as hepatic metabolism of drugs and renal excretion is decreased. Females have increased sensitivity to opioids, that may be mediated by peripheral chemoreflex pathway. Increased sedation is a precursor of OIRD and is a good early warning sign of OIRD. In patients with underlying risk factors for OIRD, the dose of opioids should be carefully titrated and enhanced monitoring of sedation levels, respiratory rate, $SpO_2$, and $CO_2$ levels may be needed in the first 24 hours after surgery.

**Conclusion**: In this review, the overall incidence of OIRD is 0.5%. Identification of patients at risk of OIRD will allow better risk stratification, intervention and resource allocation.

**References:**

1. Lee L et al. Postoperative opioid-induced respiratory depression: A closed claims analysis. Anesthesiology 2015;122:659-65

**Table. Characteristics of studies with postoperative opioid induced respiratory depression**

| Author & Year of publication | Study type | Types of respiratory events | Total patients (n) | Patients with RD (n) | RD incidence | OIRD 24h post-surgery % (n) | Site of RD | Age (yr) % (n) | Female % (n) |
|---|---|---|---|---|---|---|---|---|---|
| Rosenfeld 2016 | Retrospective review | Naloxone for opioid induced RD and/or excessive sedation | 28,151 | 108 | 0.38% | 61% (66) | Ward, ICU | 64±15 | 52% (56) |
| Weingarten 2016 | Retrospective case control | Naloxone for RD [apnea ≥10 sec, hypopnea, RR<8/min, $SpO_2$ <90%, pain-sedation mismatch] or excessive sedation | 164,809 | 413 | 0.25% | 100% (413) | PACU | 61±16 | 54% (221) |
| Weingarten 2015 | Retrospective review | Apnea ≥10 sec, hypopnea, RR<8/min, $SpO_2$< 90%, pain-sedation mismatch | 11,970 | 2,836 | 23.70% | 100% (2836) | PACU | 65±12 | 51% (1434) |
| Weingarten 2015 | Retrospective case control | Naloxone for RD [apnea ≥10 sec, hypopnea RR <8/min), $SpO_2$< 90%, pain-sedation mismatch] or | 84,553 | 134 | 0.16% | 82% (110) | Ward 83% ICU 17% | 65±15 | 58% (78) |

| | | excessive sedation | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Menendez 2015 | Retrospective review | Respiratory failure | 40,060 | 341 | 0.85% | N/A | N/A | N/A | N/A |
| Khelemsky 2015 | Retrospective cohort | Naloxone administered | 442,699 | 433 | 0.10% | Majority first 24h | PACU, Ward | 60 ± 16 | 60% (260) |
| Lee 2015 | Retrospective closed claims | Naloxone for reversal of RD, respiratory arrest, need for resuscitation, over-sedation, RR <8/min, $SpO_2$ <90%, airway obstruction /snoring /cyanosis requiring intervention, cardiopulmonary arrest, without another identified cause | 9,799 insurance claims | 92 claims | N/A | 88% (81) | Ward | 50 ± 18 ≥ 50 - 44% (37) | 57% (52) |
| Ramachandran 2011 | Retrospective cohort | Naloxone for unresponsiveness/ hypoxia / apnea during concurrent opioid therapy, cardiac arrest due to respiratory depression | 87,650 | 32 Reversible 88% Irreversible 12% | 0.038% | 81% (26) | PACU 16% Ward- 84% | 52 (18-87) | 56% (18) |
| Blake 2008 | Prospective cohort | Apnea >10 sec, hypopnea <30% of preceding flow amplitude for >10 sec and oxygen desaturation of 4%, $SpO_2$< 90%, upper airway obstruction | N/A | N/A | N/A | 100% (33) | PACU | 61 (23-82) >50 OR 8.51 CI 1.66-43.62 P=0.01 | 42% (14) |

| Overdyk 2007 | Prospective, observational | $SpO_2 < 90\% \geq 3$ consecutive min, RR < 10/min ≥ 3 consecutive min | 178 | Desat. 21 bradypnea: 73 | Desat 12%, bradypnea 41% | N/A | PACU, Ward | $SpO_2$ <90%, > 65 – 13% (24) P<0.05 | N/A |
|---|---|---|---|---|---|---|---|---|---|
| Gordon 2005 | Retrospective review | Naloxone for $SpO_2$ <90%, excessive sedation, hypotension, other side effects | 10,511 | 56 | 0.53% | 65% (36) | Ward, ICU | 60 ± 16 | 64% (36) |
| Taylor 2005 | Retrospective case control | Naloxone for reversal of opioid induced RD ($SpO_2$ <90%, RR <10/min) | N/A | 62 | N/A | 77% (48) | N/A | 68± 16 ≥ 65 - 59%(37) OR 2.34 95% CI: 1.14-4.82 p=0.019 | 61% (38) OR 0.93.95% CI: 0.45-1.93 |
| Etches 1994 | Retrospective case series | Naloxone for reversal of opioid induced RD (unresponsive, cyanosis, $SpO_2$ 40-80%, RR 4-8/min, $PaO_2$ < 80mmHg, $PaCO_2$ >55mmHg, excessive sedation, upper airway obstruction) | 1,600 | 8 | 0.50% | 100% (8) | PACU-25% Ward-75% | M - 55 (27-85) > 60 - 38% (3) | 38% (3) |
| Total | | | 871,912 | 4,337 | 0.50% | | | | |

Age expressed as mean ± SD or range, CPR: cardio-pulmonary resuscitation    ET: endotracheal intubation   RD: Respiratory depression     RR: respiratory rate   PACU: post-anesthesia care unit   ICU: intensive care unit   N/A: not applicable n: number m: median OR: odd ratio CI: confidence interval. Desat: desaturation

# A Simple Nasal PAP Mask Assembly Maintained Spontaneous Ventilation and Oxygenation in a Morbidly Obese Patient with OSA and History of Sedation-Induced Apnea and Severe Desaturation During Repeated Colonoscopy

**Presenting Author**: James Tse, PhD, MD, Department of Anesthesiology, Rutgers Robert Wood Johnson Medical School, New Brunswick, NJ, USA

**Co-Authors**: Jessica Grevesen, CRNA, APN, MSN, Ryan Sison, MD and Rose Alloteh, MD, Department of Anesthesiology, Rutgers Robert Wood Johnson Medical School, New Brunswick, NJ, USA

**Introduction:** Patients under monitored anesthesia care (MAC) often receive intravenous sedation and supplemental $O_2$ via nasal cannula. Over-sedation and/or airway obstruction may cause oxygen desaturation, especially in obese patients with obstructive sleep apnea (OSA). In severe cases, the procedures have to be interrupted in order to resuscitate the patient. A simple nasal PAP mask assembly using a pediatric mask and existing anesthesia equipment and machine has been shown to maintain spontaneous ventilation and improve oxygenation in sedated obese patients with OSA .[1-5]

We report its use in a morbidly obese patient with OSA and history of sedation-induced apnea and severe oxygen desaturation during colonoscopy under MAC.

**Case Description**: A 60 year-old male, 6'1", 342 lb, (BMI 46 kg/m$^2$) with hypertension on metoprolol and furosemide, a history of atrial fibrillation s/p ablation, OSA on nocturnal CPAP support presented for outpatient colonoscopy. His previous colonoscopy was aborted because of severe oxygen desaturation due to apnea with sedation. He was advised by the previous anesthesiologist to inform the future anesthesia care team of that desaturation episode. He had a Mallampati Class III airway, 3 cm mouth opening and full range of motion of the neck.

After the patient assumed LLD position, an infant mask (size #2) with fully inflated air cushion was secured over his nose with elastic head straps and connected to an anesthesia breathing circuit and the anesthesia machine (Photo). The APL valve was adjusted to deliver 8-10 cm $H_2O$ CPAP with 10 L/min $O_2$ flow.

Following nasal mask pre-oxygenation, his $SpO_2$ increased from 96% to 100%. Deep sedation was then titrated slowly with midazolam (2 mg), lidocaine (100 mg) and propofol boluses (3x50 mg) and propofol infusion (150 mcg/kg/min). At the beginning of colonoscopy, his BP increased from 165/101 to 185/94 mm Hg and HR from 74 to 78. Propofol infusion was briefly increased to 200 mcg/kg/min and his $SpO_2$ only decreased to 98% for 5 minutes. Small boluses of metoprolol (a total of 5 mg) were given and his BP maintained at 150's-160's/70's-90's and his HR 60's-70's. He maintained spontaneous ventilation with respiratory rate of 18-22 breaths/min and 99-100% $SpO_2$ throughout the 36-minute colonoscopy. He tolerated the procedure well without any complication. He was elated that colonoscopy was completed and oxygen desaturation was avoided. He was discharged home without any problem.

**Discussion:** This simple nasal PAP mask assembly maintained spontaneous ventilation and improve oxygenation in a morbidly obese patient with OSA and previous sedation-induced apnea and severe desaturation. It utilizes a pediatric face mask and the existing anesthesia equipment/machine and takes <2 minutes to prepare. With a tight nose-mask seal and APL valve adjustment, low flow of $O_2$ (4 L/min) is often needed to provide optimum CPAP. It can also be used to deliver immediate assisted nasal ventilation in case of apnea and may improve patient safety at a low cost.

Case reports are IRB-exempted. A patient's consent was obtained for photography.

**References:** 1.www.TSEMask.com; 2.SAMBA 28th AM:MC, 2013; 3.SASM 3rd AM:MC, 2013; 4.NYSSA 67th PGA:MCC-7189, 2013; 5.ASA AM:MC-2201, 2015

# Apnea and Severe Chest Rigidity Caused by Excessive Remifentanil due to Syringe-Pump Malfunction in a Sedated Patient with OSA During SVT Ablation

**Presenting Author**: Rose Alloteh, MD**,** Department of Anesthesiology, Rutgers Robert Wood Johnson Medical School, New Brunswick, NJ, USA

**Co-Authors**: Samantha Malanowski, MD, Nicole Grayer, MD and James Tse, PhD, MD, Department of Anesthesiology, Rutgers Robert Wood Johnson Medical School, New Brunswick, NJ, USA

**Introduction:** Anesthesiologists face many challenges in non-OR anesthesia (NORA) locations and have to be extra vigilant even performing routine procedure sedation. A simple nasal PAP mask assembly has been shown to maintain spontaneous ventilation and oxygenation in sedated patients with OSA.[1-5] We reported a near-miss in a sedated OSA patient caused by remifentanil syringe-pump malfunction in the Cardiac Cath Lab.

**Case Description:** A 74-year-old male with CAD, HTN, HLD, OSA, non-compliant with CPAP, poor exercise tolerance and SVT presented for EPS/ablation under sedation. He had a Class I airway and BMI 31 kg/m$^2$. He was consented for photography and case report.

An infant mask was secured over his nose with head straps and connected to a long breathing circuit and the anesthesia machine. Following nasal mask pre-oxygenation with 4 $LO_2$ /min and 6-8 cm $H_2O$ CPAP, his $SpO_2$ increased from 93% to 99%. He was sedated and maintained spontaneous ventilation and 99-100% $SpO_2$ with 2 mg midazolam, 25 mg diphenhydramine, 40 mg lidocaine, 30 mg propofol and remifentanil infusion (0.03 mcg/kg/min). He tolerated local anesthetic injection and femoral vein catheterization. While starting IV acetaminophen, fluid was noted to back up into the bottle. It was quickly found out that the syringe was injecting in a rapid pace. It was quickly stopped. However, it immediately restarted injecting by itself. Three-way stopcock connected to remifentanil syringe was then turned to off position and all IV fluids were shut off, disconnected from the short catheter/connecting cap and discarded.

In <2 minutes, his respiration stopped as indicated by disappearance of $ETCO_2$ and movement of the inverted reservoir bag and his $SpO_2$ was decreased from 99% to 96%. Nasal mask and LMA ventilation were unable to deliver any breath. With nasal mask continued to provide oxygen, direct laryngoscopy revealed a Class IV laryngeal view and one attempt to intubate failed. Video-laryngoscopy assisted intubation was successful with one attempt. However, manual ventilation was initially difficult and unable to obtain $ETCO_2$ and chest wall movement. Ventilation was improved after several breaths and his $SpO_2$ improved from 50-60% to 98%. His hemodynamics was stable throughout the incident. Naloxone 0.2 mg was given and EPS/ablation proceeded under GA. He tolerated the 5-hour procedure well and was extubated awake without any complication.

Biomedical engineer revealed that the syringe-pump delivered 17 ml of remifentanil (50 mcg/ml) in 28 seconds after initial 9-minutes of normal function.

**Discussion:** The syringe-pumps may often display malfunction warning and require biomedical engineer's attention. It is rare to observe rapid injection by itself. However, when it happens, it is

very dangerous while delivering potent medication such as remifentanil, propofol or vasoactive agents. It was so fortunate that most of the delivered remifentanil back-filled into the acetaminophen bottle and the infusion catheter without one-way-valve. The nasal PAP mask assembly might have improved patient safety by providing extra $O_2$ reserve and apneic oxygenation during this episode of remifentanil-induced apnea and chest rigidity.

**References**: 1.www.TSEMask.com; 2.SAMBA 28th AM:MC, 2013; 3.SASM 3rd AM:MC, 2013; 4.NYSSA 67th PGA:MCC-7189, 2013; 5.ASA AM:MC-2201, 2015

# Minute Ventilation Prior to Opioid Dose as a Predictor of Opioid-Induced Respiratory Depression in the PACU

**Presenting Author:** A. Alexa [1], MD

**Co-Authors:** Y. Martin[1], MD, A. Cavalcante [1], MD  J. Brayanov [2], PhD J. Sprung [1], MD T. Weingarten [1], MD

[1]Mayo Clinic, Rochester, MN, [2]Respiratory Motion, Inc., Waltham, MA

**General Aim:** We evaluated the ability of pre-opioid Minute Ventilation (MV) measurements reported by a non-invasive respiratory volume monitor (RVM) to identify postoperative patients who would go on to develop opioid-induced respiratory depression (OIRD).  We also evaluated the capability of the following clinical criteria to identify patients "at risk" for OIRD: ASA PS Classification, OSA diagnosis, Flemons' criteria, BMI and age.

**Background:** Postoperative pain in the post anesthesia care unit (PACU) is commonly treated with opioids, which can result in complications such as opioid-induced respiratory depression (OIRD). Here, we sought to evaluate the ability of pre-opioid MV measurements to identify patients at risk for OIRD. We also compared the predictive ability of pre-opioid MV with the predictive ability of commonly used parameters: Flemon's criteria or Sleep Apnea Clinical Score (SACS), Obstructive Sleep Apnea (OSA) history, BMI and age as predictors of OIRD.

**Methods:** Impedance-based respiratory traces were acquired using an RVM (ExSpiron, Respiratory Motion, Waltham, MA) in 107 non-intubated patients during their PACU stay following general anesthesia. Predicted MV ($MV_{PRED}$) was calculated based on gender and BSA for each patient. A "Low Minute Ventilation event" (LMVe) was defined as MV < 40% $MV_{PRED}$ sustained for at least 2 minutes. LMVe occurring within 30 minutes after administration of an opioid was used as a proxy for OIRD. Pre-opioid MV was defined as the average MV over the 5 minutes before opioid administration. Patients were classified "At-Risk" or "Not-At-Risk" for OIRD based on: (1) Pre-opioid MV, (2) ASA PS Classification, (3) OSA history, (4) SACS score, (5) BMI and (6) Age.

**Results:** Forty-five patients out of 107 (42%) received at least one opioid dose during their PACU stay, which averaged 1.23 ± 0.62 hours. Of the 45 patients receiving opioids, 12 had a history of OSA or SACS score greater than 15, 24 had an ASA PS Classification of 3 or 4, 24 had a BMI > 30, and 9 were over the age of 70. Thirteen patients out of 45 (29%) experienced an LMVe within 30 minutes of an opioid dose. Figure 1 shows the receiver operating characteristic (ROC) curve for a classifier based on pre-opioid MV when stratifying patients "at risk" for OIRD. Using a threshold value of 70% $MV_{PRED}$, sensitivity could be maximized at a value of 1, while maintaining a specificity of 0.81. Note that, the corresponding negative predictive value is 1 with a corresponding positive predictive value of 0.68. Similar analysis assessing the performance of ASA PS Classification, SACS score, BMI and age yielded predictors with ROC curves similar to the performance of random classifier.

**Conclusion:** Continuous monitoring of MV can aid assessment of respiratory status and serves as a good predictor of the development of OIRD. Classification schemes based on ASA PS Classification, SACS Scores, OSA diagnosis, BMI and age failed to produce classifiers that were simultaneously sensitive and specific regardless of threshold values. Using the RVM,

patients "at risk" for OIRD may be identified early in the post-operative period and can potentially improve patient safety.
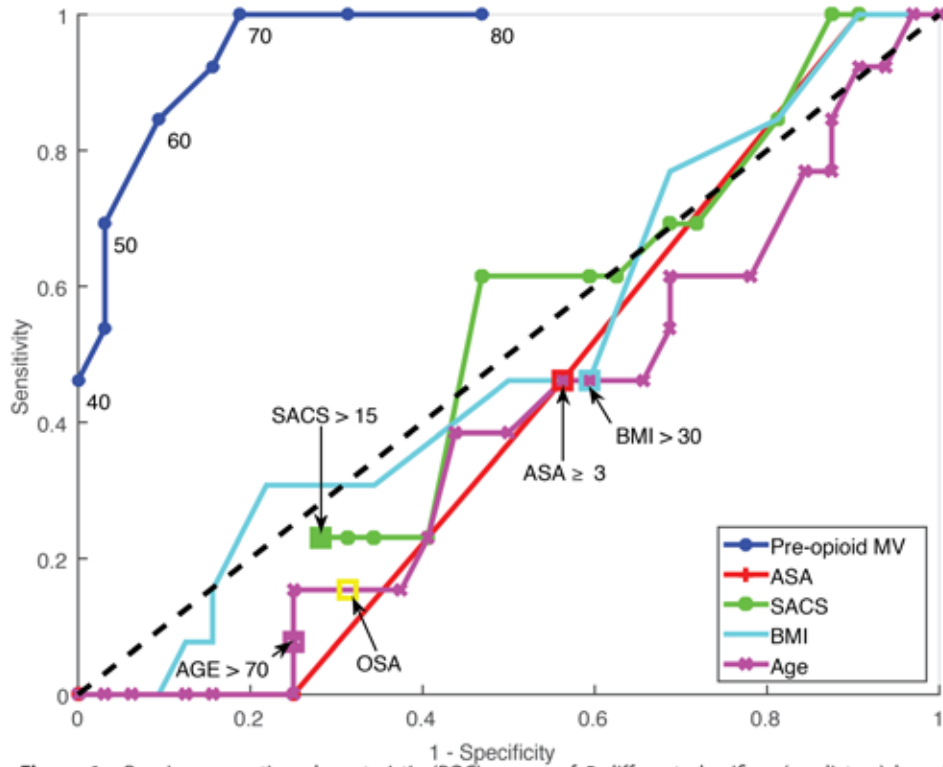


**Figure 1:** Receiver operating characteristic (ROC) curves of 5 different classifiers (predictors) based on: Pre-opiod MV measurements (blue), ASA PS Classification (red), SACS Scores (green), BMI (cyan) and age (magenta) used to stratify patients into "At-Risk" and "Not-At-Risk" for OIRD. Dashed black line indicates the performance of a random chance classifier.

# Association of Difficulty Airway in Patients with Obstructive Sleep Apnea: A Systematic Review and Meta-Analysis of Prospective and Retrospective Cohort Studies

**Presenting Author:** Mahesh Nagappa*

**Co-Authors:** David T Wong**, Crispiana Cozowicz[+], Satya Krishna Ramachandran†, Stavros Memtsoudis‡, Frances Chung**


*Department of Anesthesiology and Perioperative medicine, London Health Sciences Centre and St. Joseph's Health care, Western University, London, Ontario, Canada

[+]Department of Anesthesiology, Hospital for Special Surgery, Weill Cornell Medical College New York, NY, USA; Perioperative Medicine and Intensive Care Medicine, Paracelsus Medical University, Salzburg, Austria

†Department of Anesthesia, Critical Care and Pain Medicine, Harvard Medical School at Beth Israel Deaconess Medical Center, Harvard University, Boston, Massachusetts

‡Department of Anesthesiology, Weill Cornell Medical College and Hospital for Special Surgery, New York, NY, USA

**Department of Anesthesiology, Toronto Western Hospital, University Health Network, University of Toronto, Toronto, Ontario, Canada

**Background**: Difficulty airway is a major risk factor for perioperative mortality and morbidity. Obstructive sleep apnea (OSA) can be one of the predictive factor and may be associated with difficulty airway.

**Objective:** The aim of this systematic review and meta-analysis (SRMA) is to determine the association of difficulty airway in patients with OSA versus no-OSA.

**Methods:** The following data bases were searched from 1946 to September 31, 2016 to identify the eligible articles: Cochrane Central Register of Controlled Trials, MEDLINE, PubMed, Cochrane Databases of Systematic Reviews, Medline-in-Process & other non-indexed citations, Google Scholar, Embase, Web of Sciences and Scopus. We included only original studies (1) that used the polysomnography, chart or clinical diagnoses and screening questionnaires to diagnose/suspect OSA (2) that reported at least one difficulty airway event (difficulty mask ventilation, difficulty intubation, failed LMA insertion and surgical airway) in the OSA and no OSA groups; (3) that are either prospective or retrospective cohort studies; and (4) that included adult surgical population aged 18 years and above. We used a random-effects analysis to evaluate the existing evidence of difficulty airway in relation to OSA and to assess the association of difficulty airway with the identified/suspected OSA by study design and methodologies.

**Results**: This SRMA was conducted using 14 cohort studies. Of these, 12 studies provided data on difficulty intubation (total 19,581: 1,775 OSA vs. 17,806 non-OSA), 5 studies on difficulty mask ventilation (total 71,489: 4,890 OSA vs. 66,599 non-OSA) and two study on failed supraglottic airway (total 15832: 662 OSA vs. 15,170 non-OSA). Overall, difficulty intubation were 3.44-fold higher in the OSA patients when compared to non- OSA patients (pooled OR

3.44; 95% CI: 2.28 to 5.18, P <0.00001, I²=49%). The difficulty mask ventilation was 3.6-fold higher in OSA vs. non-OSA patients (pooled OR 3.6; 95% CI: 2.82 to 4.59, P <0.00001, I²=27%). There was no significant difference in the LMA failure rates in OSA patients compared to non-OSA patients (OSA vs. non-OSA: 1.5% vs. 1.0%; p = 0.38). Meta-regression to adjust for baseline cofounding factors and subgroup analysis did not materially change the results.

**Conclusion:** This SRMA suggests that OSA is related with higher risk of difficulty airway when compared to no-OSA patients.

**Reference**

1. Kim et al. Can J Anesth 2006: 53 (4); 393–397.

| Study or Subgroup | OSA Events | OSA Total | No OSA Events | No OSA Total | Weight | Odds Ratio M–H, Random, 95% CI | Year |
|---|---|---|---|---|---|---|---|
| **1.1.1 Difficulty Intubation** | | | | | | | |
| Hiremath et al. 1998 | 8 | 10 | 7 | 20 | 4.0% | 7.43 [1.23, 45.01] | 1998 |
| Brodsky et al. 2002 | 6 | 44 | 6 | 56 | 7.6% | 1.32 [0.39, 4.40] | 2002 |
| Siyam et al. 2002 | 8 | 36 | 2 | 77 | 4.9% | 10.71 [2.14, 53.56] | 2002 |
| Sabers et al. 2003 | 18 | 234 | 11 | 234 | 13.1% | 1.69 [0.78, 3.66] | 2003 |
| Kim et al. 2006 | 15 | 90 | 3 | 90 | 7.0% | 5.80 [1.62, 20.81] | 2006 |
| Kheterpal et al. 2006 | 18 | 700 | 66 | 13670 | 17.9% | 5.44 [3.21, 9.21] | 2006 |
| Chung et al. 2008 | 22 | 22 | 10 | 11 | 1.4% | 6.43 [0.24, 171.42] | 2008 |
| Shah et al. 2012 | 1 | 7 | 39 | 493 | 3.0% | 1.94 [0.23, 16.53] | 2012 |
| Acar et al. 2014 | 11 | 83 | 3 | 117 | 6.7% | 5.81 [1.57, 21.52] | 2014 |
| Toshniwal et al. 2014 | 25 | 93 | 0 | 24 | 1.8% | 18.24 [1.07, 311.15] | 2014 |
| Carso et al. 2014 | 91 | 455 | 284 | 2997 | 23.6% | 2.39 [1.84, 3.10] | 2014 |
| Gokay et al. 2016 | 12 | 48 | 6 | 78 | 9.1% | 4.00 [1.39, 11.53] | 2016 |
| **Subtotal (95% CI)** | | 1822 | | 17867 | 100.0% | 3.52 [2.38, 5.22] | |
| Total events | 235 | | 437 | | | | |

Heterogeneity: Tau² = 0.15; Chi² = 19.27, df = 11 (P = 0.06); I² = 43%
Test for overall effect: Z = 6.27 (P < 0.00001)

| Study or Subgroup | OSA Events | OSA Total | No OSA Events | No OSA Total | Weight | Odds Ratio M–H, Random, 95% CI | Year |
|---|---|---|---|---|---|---|---|
| **1.1.2 Difficulty mask Ventilation** | | | | | | | |
| Kheterpal et al. 2006 | 56 | 700 | 294 | 13670 | 35.9% | 3.96 [2.94, 5.32] | 2006 |
| Kheterpal et al. 2009 | 20 | 3680 | 57 | 49361 | 17.5% | 4.73 [2.84, 7.88] | 2009 |
| Shah et al. 2012 | 2 | 7 | 37 | 493 | 2.1% | 4.93 [0.92, 26.28] | 2012 |
| Carso et al. 2014 | 104 | 455 | 284 | 2997 | 42.3% | 2.83 [2.20, 3.64] | 2014 |
| Gokay et al. 2016 | 7 | 48 | 2 | 78 | 2.2% | 6.49 [1.29, 32.68] | 2016 |
| **Subtotal (95% CI)** | | 4890 | | 66599 | 100.0% | 3.60 [2.82, 4.59] | |
| Total events | 189 | | 674 | | | | |

Heterogeneity: Tau² = 0.02; Chi² = 5.50, df = 4 (P = 0.24); I² = 27%
Test for overall effect: Z = 10.31 (P < 0.00001)

| Study or Subgroup | OSA Events | OSA Total | No OSA Events | No OSA Total | Weight | Odds Ratio M–H, Random, 95% CI | Year |
|---|---|---|---|---|---|---|---|
| **1.1.3 Difficulty Supraglottic Airway** | | | | | | | |
| Ramachandran et al. 2012 | 9 | 650 | 161 | 15145 | 100.0% | 1.31 [0.66, 2.57] | 2012 |
| **Subtotal (95% CI)** | | 650 | | 15145 | 100.0% | 1.31 [0.66, 2.57] | |
| Total events | 9 | | 161 | | | | |

Heterogeneity: Not applicable
Test for overall effect: Z = 0.78 (P = 0.44)

Odds Ratio M–H, Random, 95% CI
0.05   0.2   1   5   20
Favours [OSA]   Favours [NO OSA]

# Should the New Algorithm of Stop-Bang Improve Preoperative Detection of Severe OSA? A Comparison with Other Clinical Scores

**Presenting Author:** Gabriel THIERRY, MD[1]

**Co-Authors:** Mieke VANHOONACKER, MD[2], Stephanie DEGEY, MHS[3], Jean-Francois BRICHANT, MD, PhD[1], Eric DEFLANDRE, MD, FCCP[1,2,3]

[1] University of Liege, Liege, Belgium
[2] Clinique Saint-Luc of Bouge, Namur, Belgium
[3] Cabinet Medical ASTES, Jambes, Belgium

**Background:** Obstructive Sleep Apnea (OSA) is a common risk factor for perioperative complications, especially for patients with severe OSA (sOSA)[1]. An Apnea Hypopnea Index (AHI) greater than 30 events per hour of sleep is the parameter that defines sOSA patients. Several clinical scores have been proposed to detect OSA patients (STOP-Bang[2], P-SAP[3], OSA 50[4], and DES-OSA[5]).

**General Aim:** Recently, *Chung et al.* proposed a new algorithm (practical approach) for the detection of OSA high-risk patients[6] (we called it "New STOP-Bang"). The aim of our study was to evaluate the improvement of the "New STOP-Bang" in its ability to detect sOSA. We also compared the STOP-Bang (in its classical approach, and in its new approach) to the three other clinical scores in the same ability (detection of sOSA), and this in the same preoperative population.

**Materials and Methods:** We enrolled prospectively 233 patients scheduled for elective surgery. During the preoperative anesthesia visit, an investigator collected the screened scores. All patients underwent an overnight polysomnography (PSG). A blinded investigator correlated results of the clinical scores with the AHI derived from the PSG. Scores were statistically compared using sensitivity, specificity, Youden Index, Positive Predictive Value, Negative Predictive Value, Positive Likelihood Ratio, Negative Likelihood Ratio, and the Kappa Coefficient of Cohen. A P value lower than 0.05 was considered as significant.

**Results:**

Table 1 provides complete results of our study.

Firstly, we compared the new approach of the STOP-Bang score with the original one in their ability to detect sOSA. The new approach slightly improves its sensitivity (not significant) but significantly decreases its specificity [95% CI] (0.31 [0.24-0.39] *vs* 0.47 [0.39-0.55]). Youden Index is significantly lower with the new approach (0.21 [0.16-0.26] *vs* 0.33 [0.27-0.39]). Similarly, Kappa Coefficient of Cohen is significantly lower with the new approach (0.18 [0.13-0.23] *vs* 0.30 [0.24-0.36]).

Secondly, we compared the five scores (the original and the new approach of STOP-Bang, P-SAP, OSA50, and DES-OSA) in their ability to detect sOSA. OSA50 has the best sensitivity (0.99 [0.93-1] and is significantly greater than STOP-Bang (original approach), and DES-OSA. DES-OSA has the best specificity (0.75 [0.67-0.81]), the best Positive Likelihood Ratio (3.27 [2.92-3.62]), the best Youden Index (0.57 [0.50-0.63]), and the best Kappa Coefficient of Cohen (0.55 [0.48-0.61]). These four parameters are significantly greater in DES-OSA compared to the four other scores.

**Discussion and Conclusion:** In our population and regarding the ability to detect severe OSA patients, the new approach of the STOP-Bang does not provide a significant improvement. For many parameters, the original approach seems to be more accurate in that concern. With regard of the Youden Index, and the Kappa Coefficient of Cohen, DES-OSA appears to surpass the four other scores in their ability to detect severe OSA patients. Another study on a larger scale must confirm the results of the present one.

**Clinicaltrial.gov:** NCT03172806

<u>**Table 1:**</u> **Comparison of clinical scores in their ability to detect severe OSA (AHI > 30 events hr$^{-1}$).**

|  | STOP-Bang | "New" STOP-Bang | P-SAP | OSA50 | DES-OSA |
|---|---|---|---|---|---|
| Sensitivity (95% CI) | 0.860 (0.773 – 0.917)<br><br>c | 0.903 (0.823 – 0.950) | 0.946 (0.876 – 0.979) | 0.989 (0.935 – 1)<br><br>c, j | 0.817 (0.725 – 0.883)<br><br>j |
| Specificity (95% CI) | 0.471 (0.391 – 0.554)<br><br>a, b, c, d | 0.307 (0.237 – 0.388)<br><br>a, f, g | 0.300 (0.230 – 0.381)<br><br>h, i | 0.129 (0.082 – 0.195)<br><br>c, f, h, j | 0.750 (0.672 – 0.814)<br><br>d, g, i, j |
| Youden Index (95% CI) | 0.332 (0.272 – 0.392)<br><br>a, c, d | 0.210 (0.158 – 0.262)<br><br>a, g | 0.246 (0.191 – 0.301)<br><br>h, i | 0.118 (0.077 – 0.159)<br><br>c, h, j | 0.567 (0.503 – 0.631)<br><br>d, g, i, j |
| Positive Predictive Value (95% CI) | 0.519 (0.455 – 0.583)<br><br>d | 0.464 (0.400 – 0.528)<br><br>g | 0.473 (0.409 – 0.537)<br><br>i | 0.430 (0.366 – 0.494)<br><br>j | 0.685 (0.625 – 0.745)<br><br>d, g, i, j |
| Negative Predictive Value (95% CI) | 0.835 (0.787 – 0.883)<br><br>c | 0.827 (0.778 – 0.876)<br><br>f | 0.894 (0.854 – 0.934) | 0.947 (0.918 – 0.976)<br><br>c, f, j | 0.861 (0.817 – 0.905)<br><br>j |
| Positive Likelihood Ratio | 1.627 | 1.304 | 1.352 | 1.135 | 3.269 |

| (95% CI) | (1.497 – 1.757) | (1.223 – 1.385) | (1.263 – 1.441) | (1.085 – 1.185) | (2.919 – 3.619) |
|---|---|---|---|---|---|
| | a, b, c, d | a, f, g | b, h, i | c, f, h, j | d, g, i, j |
| Negative Likelihood Ratio (95% CI) | 0.297 (0.238 – 0.356) | 0.315 (0.255 – 0.375) | 0.179 (0.130 – 0.228) | 0.084 (0.048 – 0.120) | 0.244 (0.189 – 0.299) |
| | b, c | e, f | b, e, h | c, f, h, j | j |
| Kappa Coefficient of Cohen (95% CI) | 0.299 (0.240 – 0.358) | 0.182 (0.132 – 0.232) | 0.211 (0.159 – 0.263) | 0.097 (0.059 – 0.135) | 0.549 (0.485 – 0.613) |
| | a, c, d | a, g | h, i | c, h, j | d, g, i, j |

a     Significant difference between "STOP-Bang" and "New STOP-Bang"
b     Significant difference between "STOP-Bang" and "P-SAP"
c     Significant difference between "STOP-Bang" and "OSA50"
d     Significant difference between "STOP-Bang" and "DES-OSA"
e     Significant difference between "New STOP-Bang" and "P-SAP"
f     Significant difference between "New STOP-Bang" and "OSA50"
g     Significant difference between "New STOP-Bang" and "DES-OSA"
h     Significant difference between "P-SAP" and "OSA50"
i     Significant difference between "P-SAP" and "DES-OSA"
j     Significant difference between "OSA50" and "DES-OSA"

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# Impact of Different Measurements on the Ability of P-SAP, and DES-OSA Scores to Detect Severe OSA

**Presenting author:** Lucas Cester, MD[1]

**Co-Authors:** Stephanie Degey, MHD[2,] Olivier Opsomer, MD[3,] Jean-Francois Brichant, MD, PhD[1,] Eric Deflandre, MD, FCCP[1,2,3]

**Affiliations:**
[1] University of Liege, Liege, Belgium
[2] Cabinet Medical ASTES, Jambes, Belgium
[3] Clinique St-Luc Bouge, Namur, Belgium

**Background:** Severe Obstructive Sleep Apnea (sOSA) is a risk factor of perioperative complications. An Apnea Hypopnea Index (AHI) greater than 30 events per hour of sleep is the parameter that defines sOSA patients. Clinical scores such as P-SAP and DES-OSA are used to detect sOSA[1,2].

**General Aim:** The P-SAP, and DES-OSA score consider, among others, the neck circumference (NC) and the distance between thyroid and chin (DTC). We analyzed the impact of different measurements (NC, and DTC) on the ability of P-SAP and DES-OSA to detect sOSA.

**Materials and Methods:** After IRB agreement and informed patient's consent, we enrolled prospectively 1055 patients (> 18 years) scheduled for preoperative anesthesia consultation. Polysomnography was performed in 171 patients. We applied two measurements of DTC: 1) with the head in a neutral position (N), and 2) with the head in an extended position (Ex). Identically, we studied three measurements of NC: 1) at the cricoid level (Cric), 2) above the cricoid level (Up), and 3) below the cricoid level (Down). Thus, we analyzed 6 combinations of P-Sap and DES-SOA (Up-N, Up-Ex, Cric-N, Cric-Ex, Dwn-N, Dwn-Ex). For each of these 6 combinations, we evaluated the P-SAP and the DES-OSA regarding their ability to detect sOSA in terms of sensitivity (Se), specificity (Sp), Youden Index (YI), area under ROC curves (AUROC), and Kappa Coefficient (KC) of P-SAP and DES-OSA. A P value lower than 0.05 was considered significant.

**Results:** The method of measurement induces variations in P-SAP and DES-OSA values. However, within each score, these variations don't induce significant differences regarding the ability to detect sOSA (as can be seen from AUROC curves: see Figure). P-SAP was significantly more sensitive than DES-OSA in their ability to detect sOSA [95% CI]: 0.932 [0.847-0.974] vs 0.730 [0.618-0.818]. DES-OSA: 1) was significantly more specific 0.732 [0.635-0.801] vs 0.320 [0.235-0.418], 2) exhibit the best YI (significant): 0.462 [0.387-0.537] vs 0.252 [0.187-0.317], and 3) exhibit the best KC (significant): 0.457 [0.382-0.532] vs 0.230 [0.167-0.293].

**Discussion and Conclusion:** In our screened population, the method of measurement of DTC and NC influence the values of P-SAP and DES-OSA. However, within each score, these variations do not induce significant differences regarding their ability to detect sOSA. These data, never studied before, strengthen the ability of P-SAP and DES-OSA to detect sOSA. P-SAP was significantly more sensitive than DES-OSA, while DES-OSA was significantly more specific, exhibit the highest Youden Index, and the highest Kappa Coefficient. Confirmation on a larger scale should be performed.

**Clinicaltrial.gov:** NCT03047421

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2.      Deflandre E, Degey S, Brichant JF, Poirrier R, Bonhomme V: Development and Validation of a Morphologic Obstructive Sleep Apnea Prediction Score: The DES-OSA Score. Anesth Analg 2016; 122: 363-72

**Figure:** Illustration of the six ROC Curves corresponding to the different combinations of measurement of the DTC, and NC. Left side illustrates the DES-OSA score; right side illustrates the P-SAP score.
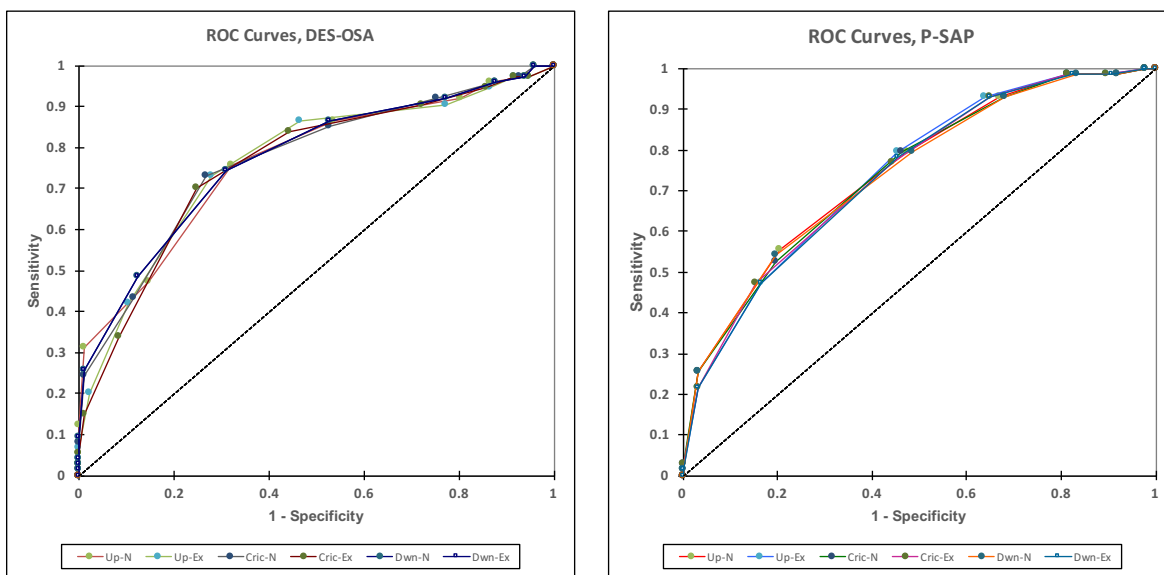
# Evaluation of Sleep Health in Pain Questionnaires Used in the Chronic Pain Population: A Systematic Review of Literature

**Presenting Author:** Mandeep Singh MD[1].

**Co-Authors:** Shreya Desai MD[1], Anuj Bhatia MD[1], Dinesh Kumbhare MD[1], Frances Chung MBBS[1], Toronto Western Hospital – Pain and Sleep Research Collaborative Group.

[1]Department of Anesthesiology, Toronto Western Hospital, University Health Network, University of Toronto

**Background:** The sleep poll of the 2015 National Sleep Foundation found that adults experiencing chronic pain attributed 35-55 % of their problems in mood, daily activities, relationships and work to sleep difficulties[1]. Using a theoretical framework of sleep health by Buysse, sleep domains have been independently associated with adverse long-term health outcomes [2]. The complex interaction between chronic pain and sleep is not well understood [3,4]. We hypothesized that sleep domains are not comprehensively evaluated in chronic pain studies. The aim of this systematic review was to evaluate whether the commonly used pain questionnaires assess sleep quality and important sleep health domains.

**Materials and methods:** A literature search was conducted using the Ovid Medline database from 1946 to May 7, 2017. The titles, abstracts and full text screening were done by two independent reviewers. Additional independent searches were also conducted in PubMed, Google Scholar and the NIH PROMIS network. The inclusion criteria were: 1) Studies involving chronic pain patients (duration longer than 6 months); 2) Validated pain assessment tools were used to evaluate impact on pain and sleep; 3) Human studies and 4) Publications in English. The exclusion criteria were pediatric population. Sleep health was assessed using Buysse's definition of *sleep quality* (the subjective assessment of good or poor sleep), *alertness* (the ability to maintain attentive wakefulness), *sleep timing* (the placement of sleep within 24 h), *sleep efficiency* (the ease of falling asleep and returning to sleep) and *sleep duration* (the total amount of sleep obtained per 24 h). The extent and quality of capture for the five main sleep domains were reported.

**Results:** A total of 1338 citations were identified, of which 423 abstracts were selected. We identified 54 validated questionnaires of which, 22.2 % (12/54) pain questionnaires included some aspects of sleep domains as part of a global sleep assessment. Sleep efficiency measured as the ease of falling asleep or returning to sleep was the most reported sleep domain (66.7%), followed by sleep quality (16.7%), duration (16.7%) and alertness (8.3%). None of the questionnaires reported sleep timing (Table 1). The Pain and Sleep Questionnaire (PSQ) assessed 3 sleep domains in addition to global assessment.

**Conclusion:** Sleep health is an under-reported component in the chronic pain population, of which sleep efficiency was the most reported domain. Future studies should report all sleep domains as part of the clinical assessments of patients with chronic pain.

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**Table 1: Summary of important findings**

| Pain Questionnaires | Study Reference | Global sleep assessment | Quality | Alertness | Timing | Efficiency | Duration | Reported by |
|---|---|---|---|---|---|---|---|---|
| American Pain Society Patient Outcome Questionnaire revised (APS-POQ-R) | Gordon 2010, McNeill 2001 | ✓ | | | | ✓ | | Self |
| Assessment of Discomfort in Dementia (ADD) | Flo 2014 | ✓ | | | | | | Nurse |
| DOLOPLUS-2 Scale | Flo 2014, Andrade 2011, Zwakhalen 2006 | ✓ | | | | ✓ | | Nurse |
| Geriatric Pain Measure (GPM) | Blozik 2007 | ✓ | | | | ✓ | | Self |
| Global Pain Scale (GPS) | Gentile 2011 | ✓ | | | | ✓ | | Self |
| Non-Communicative Patient's Pain Assessment Instrument (NOPPAIN) | Flo 2014 | ✓ | | | | | | Nurse |
| Pain and Sleep Questionnaire (PSQ) | Ayearst 2012 | ✓ | ✓ | | | ✓ | ✓ | Self |
| Pain Assessment Checklist for Seniors with Limited Ability to Communicate (PACSLAC) | Flo 2014, Zwakhalen 2006, Fuchs-Lacelle 2004 | ✓ | | ✓ | | | ✓ | Nurse |
| PROMIS Bank – Pain Interference | Davis 2016, Johnston 2016, Bartlett 2015, Stukenborg 2014, Kappelman 2014 | ✓ | | | | ✓ | | Self |
| Rheumatoid Arthritis Pain Scale (RAPS) | Anderson 2001 | ✓ | | | | ✓ | | Self |
| The Brief Pain Inventory (BPI) | Christensen 2016, Lintzeris 2016, Moscou - Jackson 2016, Davis 2016, Bredfeldt 2015, Slim 2015, Chung 2014, Vincent 2014, Mathur 2014, Erdemoglu 2013, Seicean 2013, Segal 2013, Abrams 2013, Buckenmaier 2013, Wiitavaara 2012, Salaffi 2011, Williams 2011, Manas 2011, Vallejo 2010, Chow 2010, Dhruva 2010, Wu 2010, Lee 2009, Hauser 2009, Choy 2009, Hadi 2008, Williams 2006, Zelman 2005, Gerber 2003, Klepstad 2002, Mystakidou 2001, Grossi 2001 | ✓ | | | | | | Self |
| The Chronic Pain Sleep Inventory (CPSI) | Kosinski 2007 | ✓ | ✓ | | | ✓ | | Self |

# The Usability of Dexmedetomidine as an Anxiolytic, Analgesic and Sedative Prior to and During Regional Anesthesia for the Elderly with Multiple Medical History, Who are Considered Difficult to Manage with General Anesthesia - Two Case Reports

**Presenting Author:** Natsuo Kimura, MD, Junior Resident, Kumagaya General Hospital, Japan
**Co-Authors:**
1.Natsuo Kimura, MD, Junior Resident, Kumagaya General Hospital, Japan
2.Kimie Terayama, MD, Hanyu General Hospital, Saitama, Japan
3.Yuichi Fukushima, MD, Division of Cardiac Medicine, Musashiranzan Hospital, Japan
4.Kazumasa Yasumoto, MD, PhD, Division of General Medicine, Kumagaya General Hospital, Japan
5.Shin-Chan Nakamura, MD, PhD, Division of Anesthesia, Kumagaya General Hospital, and Department of Anesthesiology, Saitama Medical University, Japan

**Introduction:** We already know that dexmedetomidine (Dx) decreases agitation and pain to some extent under its light sedative level. This report aimed to show the usability of Dx in the elderly as an anxiolytic, analgesic and sedative, and the observe the cooperation and tolerance level of elderly patients while keeping a lateral position for regional anesthesia and avoiding adverse respiratory events.

**Case presentation:** We present two cases of the complex elderly patients under regional anesthesia with Dx sedation, resulting in prevention of serious respiratory complications such as oxygen desaturation or postoperative pneumonia. We obtained consent for publication of de-identified data from both patients.

Case 1: A 78-year-old man with uncontrolled hypertension, atrial fibrillation, moderate mitral valve regurgitation, traumatic hemopneumothorax and dementia accompanied by agitation-persecution complex was scheduled for a inguinal hernia radical operation. His ASA physical status was evaluated III, and it was anticipated that the patient might be difficult to perform general anesthesia on. Therefore, we scheduled subarachnoid anesthesia (SA) with sedation used by Dx.

For induction of SA with sedation, Dx was administered as a loading infusion dose of 3µg/kg/hr for 20 min followed by the procedure of SA. Then, the infusion rate was decreased to 0.3µg/kg/hr. If necessary, the infusion rate was adjusted to maintain the light to mild sedation level. While performing SA and the entire operation, the patient was calm and cooperative without aggressive behavior. His OAA/S score was 4. His respiration rate and SpO2 were stable as well as his vital signs during the operation. After sedation, the patient exited the operation room without snoring, somnolence or unrest.

Case 2: A 66-year-old man was scheduled for an ORIF on the left femoral trochanteric fracture. The patient's past medical history included morbid obesity (Ht;163cm, BW;96kg, BMI;36kg/m2), cerebral infarction, left incomplete hemi-paralysis and severe restrictive ventilatory defect (VC:1950ml, %VC:54.7%, FEV1.0%:100%). Although the patient requested general anesthesia at first because of his past unpleasant experiences in SA, we scheduled an SA with Dx to avoid potential complications associated with general anesthesia and postoperative period due to the severe restrictive ventilatory defect. We also expected Dx would work well as an analgesic reducing the pain when we changed the position for SA.

We administered 3µg/kg/hr of Dx for 20 minutes. Dx enabled him to tolerate a lateral position for regional anesthesia. The respiration rate and SpO2 were stable during the operation, and he

exited the operation room clearly alert and with no respiratory complications. Postoperative complications were absent and he had an uneventful stay.

**Discussion:** It was somewhat difficult to decide the adaptable doses of Dx for an anxiolytic and analgesic. In the cases above, we could perform SA using Dx which could work well as an anxiolytic and sedate the patient with dementia and agitation-persecution complex. We also could confirm the analgesic effect of Dx when changing the position of the patient with femoral fracture. In conclusion, we used Dx as an analgesic-sedative drug during operation, resulting in calm and comfortable rest with negligible effects on respiration.

# Comparing Fitbit® Quality of Measured Sleep to Sleep Measured by Polysomnography in the Sleep Lab

**Presenting Author:** Mohammed Hakim, M.B.B.S., Nationwide Children's Hospital, Columbus, Ohio, United States

**Co-Authors:** Vidya T. Raman, M.D., Joseph D.Tobias, M.D., Mumin Hakim, M.B.B.S., Mark Splaingard, M.D., Nationwide Children's Hospital, Columbus, Ohio, United States

**Background:** A major risk factor in adult patients perioperatively is obstructive sleep apnea (OSA). A screening tool for OSA preoperatively is the STOP questionnaire, which allows for potential risk stratification in determining who to send for sleep polysomnography (PSG). However, this questionnaire is not applicable to pediatric patients as OSA presents differently in pediatric patients. The quality as well as cessation of breathing are important. Although PSG is the gold standard to diagnose OSA, it is a burden on families given the time and cost involved. We evaluated a commercial tool (Fitbit®) that quantifies sleep. The performance and accuracy of this tool has never been studied in pediatric patients. The Fitbit® is based on actigraphy, which has been shown to be a reliable method of quantifying sleep in adults.

**Methods:** Institutional IRB approval was obtained. Patients 3-18 years of age scheduled for a sleep study in the Sleep Lab were eligible. After obtaining informed consent, a Fitbit® was placed on the wrist of the subject when PSG testing was begun. The Fitbit® was synchronized. The Fitbit® was removed upon awakening. Data from Fitbit® and PSG were compared to identify differences in sleep time, wake time, and number of awakenings. Two-tailed paired t-tests were used to test for bias in Fitbit measurements versus PSG, while concordance correlation coefficients were used to test for agreement between Fitbit and PSG data. P<.05 was considered statistically significant.

**Results:** Nine patients have completed the study with a mean age of 9.6 ±2.5 years. Mean sleep times were 358 ± 52 minutes by PSG and 379 ± 43 minutes by Fitbit®. Mean wake times were 76 ± 49 minutes by PSG and 42 ± 22 minutes by Fitbit®. The mean number of awakenings was 9 ± 8 by PSG and 4 ± 3 by Fitbit®. No significant differences between the two methods (p = 0.138, p = 0.056, p = 0.080, respectively) were noted when comparing sleep time, awake time, and awakenings. The concordance correlation coefficient was statistically significant only for sleep time ($\rho C = 0.617$, p = 0.003), whereas concordance correlation coefficients for wake time ($\rho C = 0.208$, p = 0.264) and number of awakenings ($\rho C = 0.073$, p = 0.688) failed to reach statistical significance.

**Conclusions:** Fitbit® measurements of sleep time, wake time, and number of awakenings were not biased relative to PSG, yet concordance between the two methods was demonstrated only for total sleep time. Fitbit data on wake time and number of awakenings did not reliably correlate with PSG.

# Comparison of Fitbit® and Polysomnography for Measuring Sleep Quality After Tonsillectomy in Children

**Author:** Mohammed Hakim M.B.B.S., Nationwide Children's Hospital, Columbus, Ohio

**Co-Authors:** Mumin Hakim, M.B.B.S., Nationwide Children's Hospital, Columbus, Ohio , Mark Splaingard, M.D., Nationwide Children's Hospital, Columbus, Ohio, Joseph D.Tobias, M.D., The Ohio State University College of Medicine, Nationwide Children's Hospital, Columbus, Ohio , Vidya T. Raman, M.D., Nationwide Children's Hospital, Columbus, Ohio

**Background:** Tonsillectomy is a primary treatment option for sleep disturbed breathing (SDB) and obstructive sleep apnea (OSA) in children. Patients with unresolved symptoms of OSA or SDB may be referred for polysomnography (PSG) to plan further treatment. However, PSG is costly and intrusive, whereas commercial actigraphy devices may be used for low-cost sleep quality monitoring after tonsillectomy. We evaluated concordance of sleep quality measures between PSG and Fitbit® in children referred for PSG after tonsillectomy.

**Methods:** Children presenting for PSG with SDB symptoms and history of tonsillectomy with or without adenoidectomy were prospectively enrolled in the study. Fitbit® Charge (Fitbit Inc, San Francisco, CA, USA) was placed by an investigator and time-synchronized with sleep laboratory devices used in a single-night PSG. Total sleep time (TST) and number of awakenings were compared between PSG findings and Fitbit® data. Pearson's correlation coefficients and paired t-tests were used to describe correlation and bias of Fitbit® measurements to PSG.

**Results:** Four boys and five girls were enrolled in the study (mean age 9 ± 3 years). SDB symptoms noted at presentation included snoring (n=5), restless sleep (n=4), and sleep apnea (n=2). TST exhibited significant correlation between PSG and Fitbit® (r=0.80, p=0.010), with no evident bias in Fitbit® measurements (400 ± 34 min) compared to PSG measurements (393 ± 35 min; 95% confidence interval of difference: -10, 24 min; p=0.365). Fitbit® and PSG estimated the same average number of awakenings (3 ± 2 vs. 3 ± 4), although between-device correlation on this measure was not statistically significant (r=0.50; p=0.173).

**Conclusions:** In our pilot study addressing the feasibility of actigraphy monitoring for sleep quality in patients who had previously undergone tonsillectomy, Fitbit® measurement of sleep time was correlated with and unbiased relative to PSG findings. Long-term home monitoring of sleep quality using commercial actigraphy devices may be an accessible approach to determining further treatment when SDB symptoms remain unresolved after tonsillectomy.

# Surface Ultrasound as Screening Tool for Diagnosis of Obstructive Sleep Apnea (OSA): A Systemic Review of Literature

**Authors:** Arvind Tuteja, MBBS, DA, FICM**,** Department of Anesthesia, Toronto Western Hospital, University Health Network, University of Toronto

**Co-Authors:** Vincent Chan, MD, FRCPC, Toronto Western Hospital, UHN, UofT, Akash Goel, MD, Toronto Western Hospital, UHN, UofT, Aditya Trivedi, BSc, McMaster University, Mandeep Singh, Toronto Western Hospital, UHN, UofT

**Background:** Obstructive sleep apnea (OSA) is a common sleep disordered breathing condition that leading to upper airway obstruction, oxygen desaturation and postoperative complications.[1] Ultrasound (US) is a portable, non-invasive tool with potential for screening for obstructive sleep apnea (OSA). The objective of this systematic review is to evaluate the correlation of surface US measurements with OSA diagnosis.

**Methods:** Electronic literature search was performed in Medline, Medline In-Process, Embase, Cochrane Database of Systematic Reviews databases, and international conference abstracts. We included case series, cohort studies and randomized controlled trials of patients with known or suspected OSA using sleep study (Reference test), who underwent a surface US measurement (Index test). US parameters, scanning technique, and OSA diagnosis were recorded. The risk of bias for diagnostic tests was assessed using the QUADAS-2 tool.[2] Screening, data extraction and summarization were conducted by two independent reviewers (AT and AG), and final consensus obtained by supervising authors (MS and VC).

**Results:** Our search generated 2030 articles, of which 15 studies (13 prospective cohort and 2 cross-sectional studies) evaluating 1,948 patients met the inclusion criteria. The studies were conducted in Europe, Asia, Middle East and USA. Patients visited sleep medicine (42%), cardiology (35%), and respiratory (16%), and community clinics (7%). Using the QUADAS-2 tool, four studies were judged low risk of bias across all four domains. Of these, there was good to moderate correlation between OSA diagnosis and US parameters including carotid intimal media thickness, coronal tongue area, distance between lingual arteries, dynamic tongue base thickness during Mueller maneuver (MM), hyoid bone to hard palate length, lateral pharyngeal wall thickness, retro-palatal diameter during MM, and tongue base width, ($p<0.05$) (Table 1). No correlation was found with anterior neck, umbilical and mesenteric fat thickness and brachial artery diameter flow index ($p>0.05$) (Table 1).

**Conclusion:** Our review shows that surface ultrasound may be a useful tool for evaluation of OSA. However, large prospective studies are needed to validate and establish this tool as a screening method for OSA.

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**Table 1: Summary of findings**

| Study Name | Study Design | Sample Size & Setting | Ultrasound Variable | Results |
|---|---|---|---|---|
| Altin et al (2005) | Cohort Prospective | N=70 (Turkey) - Outpatient clinic | IMT (Intima Media Thickness) – CCA, ICA, Bulb and plaque | Strength of correlation with OSA: Good ; p value: p<0.01 for RCCA, LCCA, Lbulb; p<0.001 for LICA & Rbulb; p<0.05 for RICA) |
| Andonova et al (2012) | Cohort Prospective | N=54 (Bulgaria) - 27 with OSA and 27 controls | CCA- IMT and Plaque | Strength of correlation with AHI: Good cIMT with AHI: (r=+0.43, p<0.05) |
| Apaydin et al (2013) | Cohort Prospective | N=87 (Turkey) - Habitual simple snoring (HSS) / OSAS: AHI >5 | CCA-IMT | Strength of correlation with OSA: Moderate p value=0.03 (OSAS and HSS); No correlation between severity of OSAS and CCA-IMT (Mild-Moderate OSAS : Severe OSAS p=0.55) |
| Baguet et al (2005) | Prospective | N=83 (France) - Sleep clinic | Carotid IMT & Plaque | Strength of correlation with OSA: Moderate; p value: p 0.04 - carotid IMT/ p 0.05 - plaque formation and nocturnal oxygen desaturation |
| Ciccone et al (2011) | Cohort Prospective | N=156 (Italy) | Carotid IMT | Strength of correlation with OSA: Good; Positive relationship between IMT and OSAS duration (r=0.34;p<0.001) and between AHI and IMT (r<0.51;p<0.001). |
| Ciccone et al (2014) | Cohort Prospective | N=120 (Italy) - 80 OSA (newly diagnosed, AHI >=5); 40 controls | Carotid IMT | Strength of correlation with OSA: Good Significantly elevated cIMT in OSA compared to non-OSA and in moderate-severe OSA compared to mild OSA or control: p value: p<0.01 |
| Chen et al (2014) | Cohort Prospective | N=40 (Taiwan) - recent diagnosed sleep apnea and AHI >= 5 ; Controls: AHI<5 | Dynamic TBT (Tongue Base Thickness) | Strength of correlation with OSA: Moderate 1.TBT with MM (Muellar Manouvre) - (odds ratio: 2.11, 95% confidence interval:1.15–3.87, p<0.05) |
| Lahav et al (2009) | Cohort Prospective | N=41 (Israel) Sleep clinic Only men. | DLA (distance between lingual arteries), tongue | Strength of correlation with OSA: Good A correlation of 0.557 between DLA & AHI; p value: p<0.001 |

| | | | base width & height | |
|---|---|---|---|---|
| Shu et al (2013) | Cohort Prospective | N=105 (Taiwan) - Sleep laboratory | RP (retropalatal) & RG (retroglossal) diameter under FI (Forced Inspiration) & MM | Strength of correlation with AHI: Good Factors correlated with AHI: 1. RP diameter on MM (c=-0.624, p<0.001), 2. UAL (c= 0.581), 3. % RP shortening on MM (c= 0.584, p<0.001) |
| Wang et al (2009) | Cohort Prospective | N=90 (Taiwan) - Patients suggestive of OSA; Setting not mentioned | Tongue thickness (TT), CTA, HH Length, RG & RP diameter under FI & MM | Strength of correlation with OSA: Good Significant correlation of RP Diameter, RP shortening on MM, CTA, TT & HH Length with AHI: p value: p<0.001 |
| Ugur et al (2011) | Cross Sectional | N=97 (Turkey) – OSA patients; Tertiary care university hospital | Subcutaneous fat tissue thickness - anterior neck and umbilicus | Strength of correlation with OSA: Not Significant p value: Umbilicus-p 0.691, Submandibular gland p 0.480, Isthmus p 0.311, Hyoid p 0.159, Suprasternal Notch p 0.950 |
| Liu et al (2000) | Cohort Prospective | N=76 (Hong Kong) Respirology clinic | LPW (Lateral Pharyngeal Wall) Thickness | Strength of correlation with AHI: Good; LPW thickness - positive and independent association (r= 0.12,P= 0.002) with AHI. |
| Liu et al (2015) | Cohort Prospective | N=242 (Hong Kong) Respirology clinic | Mesenteric Fat thickness (MFT), Preperitoneal fat & Subcutaneous Fat Thickness | Strength of correlation with OSA: Moderate 1. MFT associated with increased risk of OSA (p<0.01); 2. Pre-peritoneal fat thickness showed significant correlation with AHI |
| H A Chami et al (2009) | Cross - Sectional | N=682 (Boston, USA) Framingham Heart Study site of the Sleep Heart Health Study | Arterial Diameter (BA), FMD (Flow Mediated Dilatation) | Strength of correlation with OSA: Moderate Association observed between SDB and larger BA diameter (p=0.03), but no relation between SDB and FMD |
| Siegel et al 2000 | Prospective | N=5 (USA) – OSA Patients on CPAP - Asleep patients on outpatient basis | Submental Ultrasound – Tongue Base Movement | In some subjects, obstruction may be detected earlier than PSG on US visualization of floor muscles |

AHI – Apnea-Hypopnea Syndrome; BA – Brachial Artery; CCA – Common Carotid Artery; CTA - Coronal Tongue area; CV - Coefficient of variation; DLA - Distance between lingual arteries; FI - Forced Inspiration; FMD - Flow Mediated Dilatation; HH - Hyoid Bone to Hard Palate; ICA – Internal Carotid Artery; IMT - Intima Media Thickness; LPW  - Lateral Pharyngeal Wall; MFT - Mesenteric fat  thickness; MM - Muellar Manouvre; MS - Metabolic Syndrome; OSA – Obstructive Sleep Apnea; PSG – Polysomnography; RG – Retroglossal; RP – Retropalatal; SDB – Sleep Disordered Breathing; TBT - Tongue Base Thickness; TT - Tongue thickness; UAL – Upper Airway Length

# Ethanol-Induced Changes in Spatial Navigation Correlate to Brain Anatomy in Zebrafish

**Presenting Author:** Charles Eichstaedt OMSII Kansas City University

**Co-Authors:** Richard Guidetti D.O. University of Missouri - Kansas City, Julie Mustard Kansas City University, Norbert Seidler Ph.D. Kansas City University

**Background:** Health risks associated with excessive alcohol ingestion are many, including a greater prevalence (up to 5-fold increased risk) of post-operative complications, such as cognitive impairment [1]. Furthermore, alcoholics exhibit sleep disturbance in the form of insomnia, daytime sleepiness, and disrupted sleep architecture. The societal costs of alcohol-associated sleep disorders are estimated at over $18 billion [2]. Damage to the CNS is a major complication of alcohol abuse. Zebrafish is a useful model in studying alcohol-related disorders, and how alcohol impacts the brain.

**General Aim**: This study represents a preliminary examination of the effects of repeated ethanol exposure on adult zebrafish neurobehavior, analyzing brain scans of live zebrafish subsequently tested for behavioral endpoints, such as spatial navigation.

**Materials and Methods:** Zebrafish (*Danio rerio*; wild-type AB) were handled using standard protocols (KCU IACUC#764408), and the study received approval (KCU IACUC #768180). Adult zebrafish were 537 days post fertilization at the beginning of the study. The human age equivalent is estimated to be 49 years old, using a formula previously derived [3]. Four fish divided into two groups (control and chronic ethanol ingestion) were exposed (or, mock-exposed) to 1% ethanol (10x for 1hr each over a two-week period), given a two-week washout period, scanned using optical coherence tomography (OCT), given a six-week washout period, video recorded, and assessed by the Noldus EthoVision XT 11.5 behavioral analysis system.

**Results**: Images of the pallial lobes of the caudal telencephalon were measured. Ethanol-exposed zebrafish brain measured larger than controls. Furthermore, the surface topology of the telencephalon, normally contoured evenly, was more convoluted in the ethanol-exposed zebrafish. Upon neurobehavioral assessment, the ethanol-exposed subjects exhibited more purposeless movement relative to controls.

**Discussion**: The zebrafish brain chronically exposed to ethanol appeared edematous, consistent with the hypothesis of overhydration [4] during alcohol withdrawal. This brain region contains the amygdala and the hippocampus, known for spatial navigation that was impaired in the ethanol-ingested group.

**Conclusion:** OCT is a useful non-invasive technology to examine brain morphology of zebrafish, whose neurophenotype of chronic alcoholism can then be studied in order to better correlate brain and behavior.

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# Evaluating the Sex-Specific Factors Impacting the Neck, Leg and Total Fluid Volume Distribution in Patients Having Undergone Non-Cardiac Surgery Under General Anesthesia

**Authors:** Mandeep Singh MD, University Health Network, University of Toronto, Toronto, Canada

**Co-Authors:** Azadeh Yadollahi PhD, University Health Network, University of Toronto, Toronto, Canada, Bojan Gavrilovic MHSc, University Health Network, University of Toronto, Toronto, Canada, Stuart McCluskey MD, University Health Network, University of Toronto, Toronto, Canada, Frances Chung MBBS, University Health Network, University of Toronto, Toronto, Canada

**Background**: Understanding the impact of intravenous (IV) fluid administration on rostral fluid shift and neck fluid volume may identify the physiological determinants of upper airway collapse in patients with obstructive sleep apnea (OSA) following surgery.[1-3] We hypothesized that in patients receiving general anesthesia (GA) and IV fluids after non-cardiac surgery, the neck fluid volume will change differently across sex from before and after surgery.

**Methods**: Following REB approval, adult patients ($\geq$18 yrs), ASA I-IV, undergoing elective inpatient surgery, were consented for this prospective cohort study. The exclusion criteria were: patients undergoing cardiac or neurosurgical procedures, OSA patients on treatment; and neuraxial anesthesia. The preoperative apnea-hypopnea index (AHI) was obtained using a type 3 portable sleep monitor at home. On the day of surgery, the preoperative and postoperative fluid measurements for neck fluid volume (NFV), leg fluid volume (LFV) and total fluid volume (TFV) were recorded using bioelectrical impedance analysis (BIA).[3] Patients underwent GA and surgery as per the standard of care. All measurements were conducted with the patient in supine position in the pre-operative care unit (POCU) before surgery, and within 30 minutes of arrival to the post-anesthesia care unit (PACU). Total fluid balance, type of surgical procedure, anesthetic technique and duration of surgery were recorded. Group effects of time and gender were analyzed using repeated measures ANOVA. The change in NFV, LFV, and TFV from preoperative value to the PACU time points were evaluated using paired t-test (2-sided) or Wilcoxon signed rank tests with Bonferroni correction. The analyses were stratified by sex.

**Results**: Thirty two of 144 screened patients consented for the study. Thirteen patients undergoing various non-cardiac surgeries under general anesthesia with complete data were included in this analysis. In the cohort, males were older with a lower BMI and underwent mainly general surgical and urological procedures, compared to females. There was no difference in the amount of fluids received or the fluid balance, preoperative AHI, or duration of surgery across sex. Among males, the mean NFV (p=0.002) increased significantly from POCU to PACU versus the mean LFV (p=0.7) and TFV (p=1). In females, both the mean NFV (p=0.02) and LFV (p=0.02) increased from POCU to PACU, compared to the mean TFV (p=0.12). (Figure 1) The estimates remained significant after adjusting for age, BMI, or body position in the OR.

**Conclusion:** This is the first study to demonstrate feasibility of measuring segmental fluid distributions in the neck, legs in a surgical population. The preferential increase in NFV in males compared to both NFV and LFV in females may be related to the body position inside the operative room, as well as to the higher propensity of older men for upper airway collapsibility.

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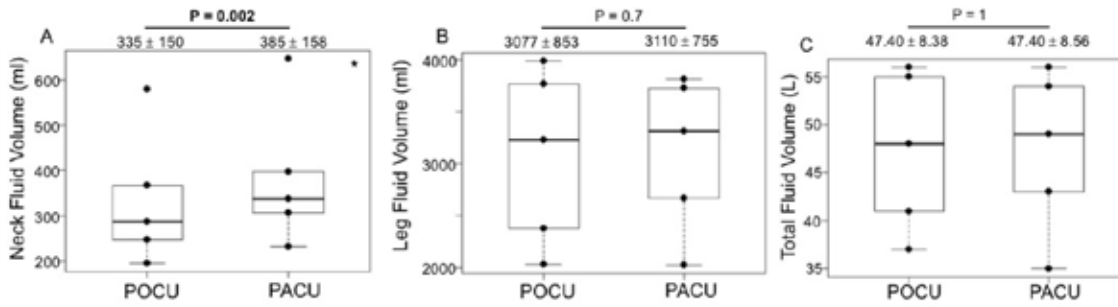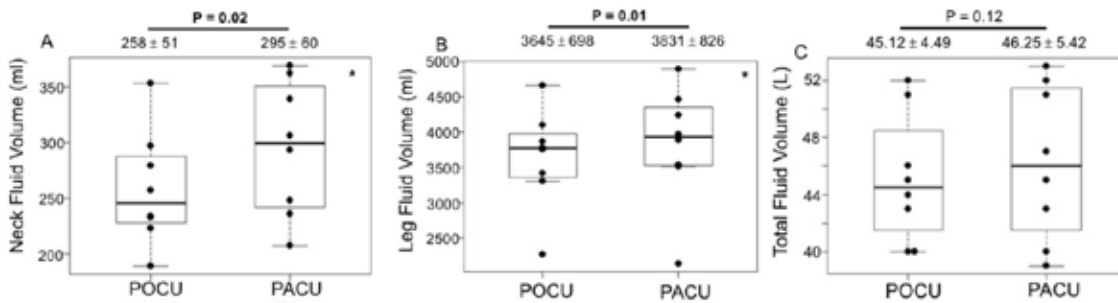
**Figure 1.** Postoperative changes in the neck fluid, total body water and leg fluid volume following general anesthesia in males (1a) and females (1b). **In males,** the neck fluid volume increased significantly despite no changes in leg fluid volume and total fluid volume. **In females,** the neck fluid volume and leg fluid volume increased significantly despite no changes in total fluid volume. POCU: pre-operative care unit: PACU: Post-anesthesia care unit

# Lack of Association Between Sleep Apnea and Postoperative Delirium Among Total Hip and Knee Arthroplasty Patients

**Presenting Author:** Sarah M. Weinstein BA[i]

**Co-Authors:** Crispiana Cozowicz MD[i,ii], Lukas Pichler MD[i,ii], Jashvant Poeran MD PhD[iii], Stavros G. Memtsoudis MD PhD FCCP[i,ii]

[i]Hospital for Special Surgery, Department of Anesthesiology, New York, NY
[ii] Paracelsus Medical University, Department of Anesthesiology, Perioperative Medicine and Intensive Care, Salzburg, Austria
[iii] Icahn School of Medicine at Mount Sinai, Institute for Healthcare Delivery Science, Department of Population Health Science and Policy, New York, NY

**Background / General Aim:** Previous research has suggested that surgical patients with sleep apnea (SA) are at significantly higher risk, compared to those without SA, for complications such as postoperative delirium.[1] In this study of patients undergoing unilateral total hip and knee arthroplasties (THA and TKA), we assessed whether this finding applied to a patient cohort in a high-volume surgical setting where the vast majority of patients receive neuraxial anesthesia. We hypothesized that in the setting where neuraxial anesthesia is primarily used, SA would not emerge as a risk factor for delirium.

**Materials and Methods:** With approval from the Hospital for Special Surgery (HSS) Institutional Review Board, we studied patients who underwent unilateral TKA or THA at HSS from 2007-2014. We merged various datasets consisting of ICD-9 codes, anesthesia, and pharmacy data and identified 39,683 surgeries. Exclusion criteria were surgeries that took place after the date of admission and whose primary anesthesia type was missing. In addition, TKA patients who had a previous THA and THA patients who had a previous TKA were excluded, in order to remove duplicate patients from the study. Finally, 37,009 unique patients (18,785 TKA and 18,224 THA) were included for analysis.

We identified patient comorbidity profiles using the Quan-Deyo comorbidity index[2] and sleep apnea using relevant ICD-9 codes. A multivariable logistic regression model was used to determine the odds ratios (OR) and 95% confidence intervals (CI) of postoperative delirium, adjusting for Quan-Deyo index, sleep apnea, demographics, surgery type, anesthesia type, and postoperative prescription medications given in the hospital ward (ketamine and benzodiazepines).

**Results:** Of the 37,009 patients in this cohort, 2,952 (7.98%) had a diagnosis of SA and 604 (1.63%) of whom developed postoperative delirium. Of those with SA, 47 (1.59%) developed postoperative delirium.

The adjusted OR of postoperative delirium for SA patients compared to non-SA patients was not statistically significant. However, the odds of delirium significantly increased with higher comorbidity burden, older age, TKA (compared to THA), general anesthesia (compared to neuraxial anesthesia), and postoperative prescription of ketamine and benzodiazepines (Table 1).
An AUC of 0.8273 suggested overall effectiveness of the model at distinguishing between patients who did and did not develop postoperative delirium.

**Discussion / Conclusion:** In contrast to other studies, we found no association between SA and postoperative delirium. The divergence of our findings may be explained by lack of similarities between the patient populations, as well as by differences in standard anesthesia practices.

In conclusion, further research will be needed to demonstrate the role of both unmodifiable and modifiable risk factors (e.g., sleep apnea, type of anesthesia) in the risk for postoperative delirium and other perioperative complications.

These results are part of an ongoing study, and we are working to expand the breadth of data sources and to increase the sample size for future analyses.

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**Table 1: Results from multivariable logistic regression, estimating OR of postoperative delirium and adjusting for covariates, including preexisting sleep apnea diagnosis**

| Variable | Reference | OR (95% CI) | *p*-value |
|---|---|---|---|
| *Comorbidity burden* | | | |
|   Sleep apnea | No sleep apnea | 1.23 (0.9-1.68) | 0.194 |
|   Quan-Deyo comorbidity index | Minus 1 index unit | 1.18 (1.06-1.31) | 0.003 |
| *Demographics* | | | |
|   Age | Minus 1 year | 1.13 (1.12-1.14) | <0.001 |
|   Female gender | Male gender | 0.93 (0.79-1.11) | 0.439 |
| *Type of surgery* | | | |
|   Total knee replacement | Total hip replacement | 1.78 (1.49-2.12) | <0.001 |
| *Type of anesthesia* | | | |
|   Combined spinal epidural | General anesthesia | 0.52 (0.34-0.79) | 0.002 |
|   Epidural | General anesthesia | 0.56 (0.33-0.97) | 0.038 |
|   Spinal | General anesthesia | 0.52 (0.32-0.85) | 0.009 |
| *Medications given in ward* | | | |
|   Benzodiazepines | Benzodiazepines not given | 3.17 (2.59-3.87) | <0.001 |
|   Ketamine | Ketamine not given | 6.92 (2.76-17.37) | <0.001 |

**AUC: 0.8273**

# Multimodal Analgesia and Opioid Prescription Levels in Sleep Apnea Patients Undergoing Total Hip and Knee Arthroplasties - A Population Based Study

**Presenting Author:** Crispiana Cozowicz MD[1.2],

**Co-Authors:** Nicole Zubizarreta MPH[3], Lukas Pichler MD[1.2], Jashvant Poeran MD PhD[3], Stavros G. Memtsoudis MD PhD[1.2].

[1] Department of Anesthesiology, Hospital for Special Surgery, Weill Cornell Medical College New York, NY, USA

[2] Department of Anesthesiology, Perioperative Medicine and Intensive Care Medicine Paracelsus Medical University, Salzburg, Austria

[3] Department of Population Health Science and Policy, Icahn School of Medicine at Mount Sinai, Institute for Healthcare Delivery Science, New York, NY, USA

**Introduction:** Multimodal analgesia, the simultaneous practice of different analgesic pathways in the context of perioperative pain management, has increasingly become the standard of care to enable improved pain control with reduced opioid consumption and diminished drug related side effects. OSA patients are particularly at risk for respiratory and other complications from analgesic drugs like opioids, which attenuate the ventilatory response. Given the widespread consensus on the importance to reduce opioid consumption in patients with sleep apnea, the implementation of multimodal pain management strategies has gained significant interest. However, data demonstrating effects on opioid prescription practices and resource utilization among patients with OSA is largely lacking. Using large claims based data, we therefore studied the potential impact of multimodal analgesia in OSA patients receiving total hip and knee arthroplasties (THA and TKA).

**Methods:** We extracted patients with an ICD-9 code for OSA undergoing THA n=32,062/ TKA n=91,608 from the national Premier Perspective database (2006-2014; 546 hospitals). Multimodal analgesia was defined as the presence of billing for a peripheral nerve block (PNB), intravenous acetaminophen, gabapentin/pregabalin, NSAIDs, COX-2 inhibitors, and ketamine on the day of surgery or the day after in addition to billing for opioids (converted into oral morphine equivalents). Multilevel multivariable models measured the association between multimodal analgesia use and opioid prescription as well as length and cost of hospitalization. Percent change (%) and p-values are reported.

**Results:** In 123,670 OSA patients undergoing THA/TKA, multivariable models showed that the utilization of multimodal analgesia in addition to opioid use, was associated with significantly decreased opioid prescription starting from postoperative day one, in contrast to sole postoperative opioid therapy.
On postoperative day one, the use of 2 or more (2+) analgesic modes in addition to opioid utilization was associated with a significant decrease in opioid prescription by 13.6% and 15.6% (p<0.002) respectively in THA, while opioid prescription decreased by 5.2% (p=0.14) and 11.9% (p<0.0001) in TKA by 2 and 2+ analgesic modes, respectively. Likewise, after postoperative day one the utilization of 1, 2 or 2+ modes of analgesia in addition to sole opioid use, significantly decreased opioid utilization by 15.9%, 25.8%, 30.3% respectively in THA (p<0.005); while in TKA opioid use decreased by 17.0%, 20.7%, and 26.8% (p<0.0001), respectively. Moreover,

length of hospital stay (LOS) significantly decreased in a stepwise manner by with the use of 1, 2 or 2+ modes of multimodal analgesia. Finally, a significant decrease in cost of hospitalization was also observed with multimodal pain management practice versus sole postoperative opioid therapy.

**Discussion:** Large-scale population based data in sleep apnea patients, demonstrated that the implementation of multimodal analgesia was associated with a significant decrease in opioid prescription starting from postoperative day 1, while this effect was even more pronounced on the following days. Importantly, multimodal analgesia was also associated with a substantial decrease in LOS and cost of hospitalization. While more research is awaited, this analysis demonstrates the efficacy of multimodal analgesia in affording perioperative opioid restriction, a measure deemed crucial in OSA.

Table 1. Multivariable analysis in THA. Changes in opioid dose prescription levels, length of stay and cost by the addition of 1, 2 or 2+ modes of analgesia to opioid utilization compared to sole opioid use for post-operative analgesia.

| | Total Hip Arthroplasty | | | | | |
| | 1 mode | | 2 modes | | 2+ modes | |
| Opioid use | % | p-value | % | p-value | % | p-value |
|---|---|---|---|---|---|---|
| POD-1 | +0.5% | 1.0000 | -13.6% | 0.0018 | -15.6% | 0.0016 |
| POD-1+ | -15.9% | 0.0041 | -25.8% | <.0001 | -30.3% | <.0001 |
| LOS | -10.9% | <.0001 | -19.9% | <.0001 | -23.3% | <.0001 |
| Cost | -5.1% | 0.0002 | -6.9% | <.0001 | -4.9% | 0.0091 |

POD postoperative day

Table 2. Multivariable analysis in TKA. Changes in opioid use, length of stay and cost by the addition of 1, 2 or 2+ modes of analgesia to opioid utilization compared to sole opioid use for post-operative analgesia.

| | Total Knee Arthroplasty | | | | | |
| | 1 mode | | 2 modes | | 2+ modes | |
| Opioid use | % | p-value | % | p-value | % | p-value |
|---|---|---|---|---|---|---|
| POD-1 | -0.8% | 1.0000 | -5.2% | 0.1396 | -11.9% | <.0001 |
| POD-1+ | -17.0% | <.0001 | -20.7% | <.0001 | -26.8% | <.0001 |
| LOS | -11.8% | <.0001 | -17.3% | <.0001 | -23.3% | <.0001 |
| Cost | -5.7% | <.0001 | -6.2% | <.0001 | -5.6% | <.0001 |

POD postoperative day

# The Perioperative Impact of Sleep Apnea in a High-Volume Specialty Practice With Focus On Regional Anesthesia

**Presenting Author:** Lukas Pichler MD[1,2]

**Co-Authors:** Sarah M. Weinstein BA[1], Crispiana Cozowicz MD[1,2], Jashvant Poeran MD PhD[3], Stavros G. Memtsoudis MD PhD[1,2].

[1] Department of Anesthesiology, Hospital for Special Surgery, Weill Cornell Medical College New York, NY, USA

[2] Department of Anesthesiology, Perioperative Medicine and Intensive Care Medicine Paracelsus Medical University, Salzburg, Austria

[3] Department of Population Health Science and Policy, Icahn School of Medicine at Mount Sinai, Institute for Healthcare Delivery Science, New York, NY, USA

**Introduction:** Obstructive sleep apnea (OSA) has been established as a risk factor for adverse postoperative outcome among perioperative societies. Moreover, the prevalence of sleep apnea appears to be high in the surgical population and particularly in orthopedic surgery. The growing awareness regarding the potential threat for adverse outcome in these patients is reflected in the abundance of guidelines and recommendations issued to prevent perioperative detriment. As such, the American Society of Anesthesiologists has advocated the use of regional anesthesia in OSA patients undergoing peripheral procedures as a measure of precaution. We therefore aimed to study the impact of OSA on postoperative complications in a high volume orthopedic surgery practice, with a strong focus on regional anesthesia.

**Methods:** Cases of primary total hip and knee arthroplasties (THA/TKA) from 2005 to 2014 were extracted from institutional, administrative data of the Hospital for Special Surgery (HSS). The study protocol was approved by the Institutional Review Board of HSS. Patients, characteristics, diagnoses, and provided procedures were identified by ICD-9 codes, and standardized billing items. Cases that took place after the date of admission (n = 254), and whose primary type of anesthesia was missing (n = 1,688) were excluded.
The outcome of interest was a potential association between OSA diagnosis and the occurrence of postoperative in-hospital adverse events including cardiac, respiratory, gastrointestinal, urinary, wound and surgical site complications, thrombosis, falls and length of stay (LOS). A multivariable logistic regression model was used to compute odds ratios (OR), corresponding 95% confidence intervals (CI) and p-values. The cutoff for statistical significance was set at 0.00625, after adjusting for multiple comparisons using Bonferroni correction. Covariates included were age, gender, anesthesia technique, meaning general or neuraxial anesthesia and comorbidities by the Quan-Deyo comorbidity index.

**Results:** After applying exclusion criteria, the dataset consisted of 39,765 unique patients (20,137 TKA and 19,628 THA). Analysis showed that the presence of OSA was associated with a significant increase in cardiac complications by about 70%. Moreover, the risk for respiratory complications was increased by more than a two-fold in patients with sleep apnea compared to non-sleep apnea patients. Furthermore, the risk for prolonged hospitalization beyond 4 days, was significantly increased by 40% in patients suffering from OSA. While the risk for falls remained unaltered by OSA diagnosis, analysis showed a trend towards increased risk for gastrointestinal, genitourinary, and wound complications.

**Discussion:** This analysis investigated associations between the prevalence of sleep apnea and the occurrence of postoperative complications in the setting of a large specialty practice over 10 years. Overall, OSA was associated with a substantial increase in risk for respiratory and cardiac complications as well as prolonged length of stay despite the predominant use of regional and avoidance of general anesthesia. These results confirm current evidence regarding the perioperative risk of OSA. Moreover, the current study underscores the significance of this condition even in a regional anesthesia setting and demonstrates the need for further evaluation of possible measure of precaution.

**Table 1.** Multivariable analysis of 39,765 patients – odds for post-operative complications in patients with OSA compared to non-OSA patients.

| Complication | Odds ratio (95% CI) |
|---|---|
| Cardiac | 1.69 (1.48-1.92)* |
| Respiratory | 2.1 (1.69-2.61)* |
| Gastrointestinal | 1.47 (1.11-1.94) |
| Genitourinary | 1.22 (0.95-1.56) |
| Wound/surgical site infection | 1.37 (0.82-2.3) |
| Thrombosis | 1.12 (0.78-1.6) |
| Falls | 1 (0.48-2.08) |
| Prolonged LOS (>4 days) | 1.4 (1.28-1.53)* |

**\* statistically significant at p<0.00625**

# Trends in the Utilization of Multimodal Analgesia Among Sleep Apnea Patients Undergoing Total Joint Arthroplasties – A Population Based Analysis

**Presenting Author:** Lukas Pichler MD,[1,2]

**Co-Authors:** Crispiana Cozowicz MD[1,2], Nicole Zubizarreta MPH[3], Jashvant Poeran MD PhD[3], Stavros G. Memtsoudis MD PhD[1,2].


[1] Department of Anesthesiology, Hospital for Special Surgery, Weill Cornell Medical College New York, NY, USA
[2] Department of Anesthesiology, Perioperative Medicine and Intensive Care Medicine Paracelsus Medical University, Salzburg, Austria
[3] Department of Population Health Science and Policy, Icahn School of Medicine at Mount Sinai, Institute for Healthcare Delivery Science, New York, NY, USA

**Introduction:** Multimodal analgesia implies a pain management approach involving several pain pathways to afford improved pain relief with concurrent decrease in opioid use and related side effects. This strategy has been introduced more than two decades ago, and benefits anticipated have rendered multimodal analgesia the new standard of best pain management practice. Given the increased threat of obstructive sleep apnea (OSA) in the perioperative setting, the call for multimodal pain strategies to particularly reduce opioid consumption, has reached widespread consensus. However, as data demonstrating real world practice of multimodal pain management in OSA is largely lacking, we aimed to study trends in the clinical implementation and the impact on opioid prescription in OSA patients undergoing joint arthroplasties.

**Methods:** Patients with an ICD-9 code for OSA undergoing total hip and knee arthroplasties (THA n=32,062 / TKA n=91,608) were identified using the national Premier Perspective database (2006-2014; 546 hospitals). Data on utilization of opioids and a peripheral nerve block (PNB), intravenous acetaminophen, gabapentin/pregabalin, NSAIDs, COX-2 inhibitors, and ketamine was used to categorize patients into four multimodal groups: 1) only opioids, and 2-4) opioids in addition to 1, 2, or 2+ analgesic modes. Annual utilization trends and hospital characteristics associated with these groups were assessed for THA and TKA separately.

**Results:** Among THA patients, 16.8% (n=5,398) received sole opioid therapy for postoperative analgesia without multimodal postoperative management, while 33.8% (n=10,833), 30.0% (n=9,629), and 19.3% (n=6,202) received opioids and 1, 2 or more than 2 additional analgesic modes, respectively. Similarly, this was 13.6% (n=12,467), 33.4% (n=30,574), 31.0% (n=28,377), and 22.0% (n=20,190) in TKA patients.

While differences by hospital characteristics appear relatively subtle, multimodal strategies seem slightly more prevalent in small and medium-sized (<300-499 beds) hospitals at a rate of 84% in THA patients, compared to 80% in larger hospitals p<0.0001); similarly, in TKA the prevalence of multimodal analgesia was 87% in small and medium-sized hospitals, while this was 84% larger hospitals, p<0.0001.
Trend analysis showed that in THA patients, the percentage of patients not receiving multimodal pain management decreased sharply from 26.2% in 2006 to 10.3% in 2014 (P<0.0001). Likewise, the use of 1 additional analgesic mode decreased from 48.3% in 2006 to 27.0% in 2014. Concurrently, the use of 2 and 2+ analgesic 'modes' in addition to opioid use increased

sharply from 21.2% and 4.3% in 2006 to 32.4% and 30.3% in 2014 (p<0.0001), respectively. Notably these developments came along with a decrease in opioid prescription (measured in oral morphine equivalents) from an average of 376mg in 2006 to 305mg in 2014 among THA patients. Similar patterns were observed for TKA patients, where opioid utilization decreased from an average of 411mg in 2006 to 331mg in 2014.

**Discussion:** Over the past decade, OSA patients undergoing total joint arthroplasties, have increasingly received a multimodal post-operative pain management approach, while levels of opioid dose prescription concurrently decreased. This particularly applied to small and medium sized hospitals. Given the call for restricting anesthetic and analgesic drugs in OSA patients, these observations seem promising.

Figure 1. Trends in THA
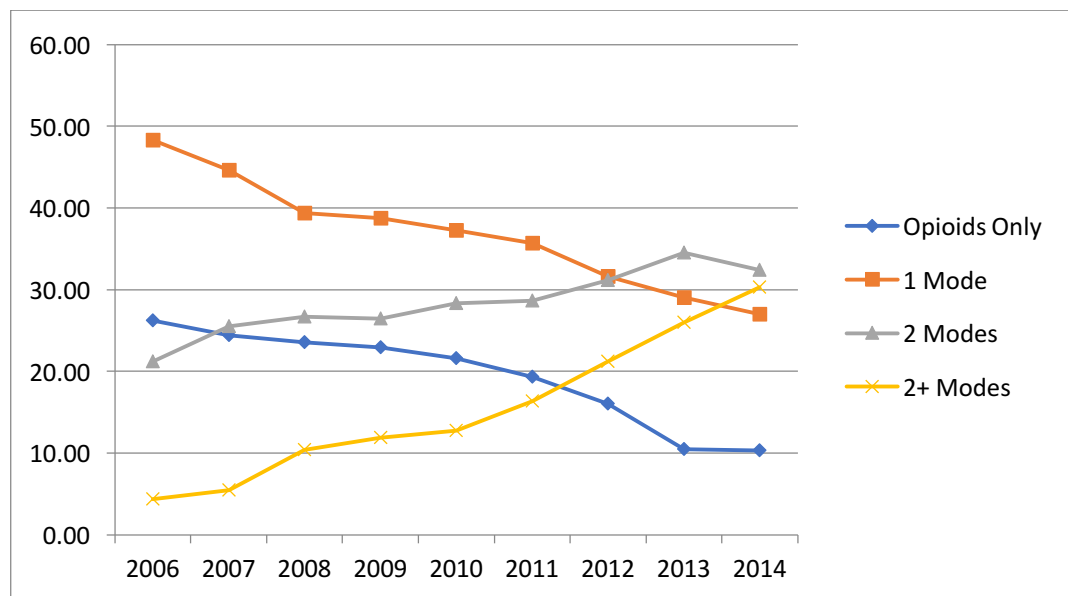


Figure 2. Trends in TKA
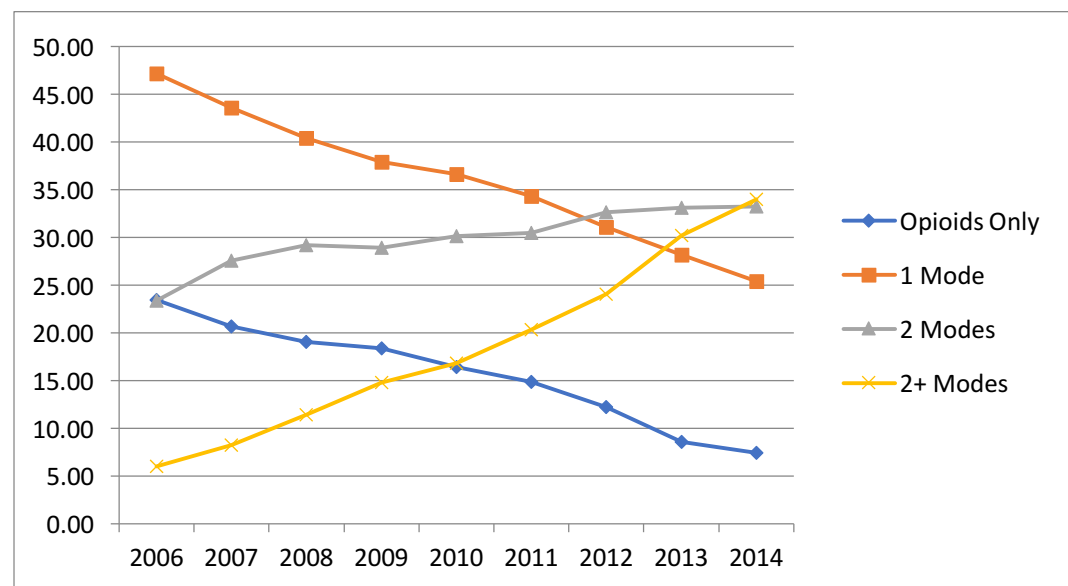
# Using the RUTGERS Scoring System to Decide the Disposition of Patients from the Post-Anesthesia Care Unit who are at Risk for Obstructive Sleep Apnea

**Presenting Author**: Mark H. Stein, MD, Rutgers- Robert Wood Johnson Medical School, New Brunswick, NJ

**Co-Authors**: Geza K. Kiss, MD, Rutgers- Robert Wood Johnson Medical School, New Brunswick, NJ, Stanley Z. Trooskin, MD, Rutgers- Robert Wood Johnson Medical School, New Brunswick, NJ

**Background**: Postoperative patients of Body Mass Index (BMI) > 35 and a STOP/BANG[1] score of ≥ 5 generally fall into one of three categories in our Post-Anesthesia Care Unit (PACU).
1. Patients whose preoperative status was reasonably satisfactory, intraoperative course uneventful, and PACU stay was uncomplicated: such patients can go home or to a regular floor.
2. Patients whose preoperative status was less than optimal, whose intraoperative course was very challenging, had multiple issues in the PACU, and in particular, those who had **more than one**[2] 'unexplained respiratory incident' in the PACU: such patients will go to a monitored setting postop where continuous pulse oximetry is available.
3. Patients who are in between categories 1 and 2- perhaps they had **one** 'unexplained respiratory incident' in the PACU, and/or their co-morbidities and other factors are cause for additional concern, and a clinical judgment is needed in order to decide their disposition beyond the PACU. A potential gray zone exists in the decision-making process.

**Aim**: For patients at risk for Obstructive Sleep Apnea (OSA) and who fall into the third category mentioned above, we have devised the RUTGERS scoring system to aid in the decision by scoring the risk factors.

**Materials and Methods**: Our PACU algorithm is used as the basis for deciding the disposition of patients at risk for Obstructive Sleep Apnea (OSA). We devised and added the RUTGERS scoring system (figure 1). A score of ≥ 3 warrants transfer to a monitored setting where continuous pulse oximetry is available.

**Results**: The algorithm, combined with the scoring system, guides practitioners in their decision making by focusing the process on the ongoing abnormalities and specific risk factors.

**Discussion**: Stratification of postoperative patients who are at increased risk for OSA-related adverse cardiopulmonary events is essential in order to most appropriately utilize the additional resources such patients require. Algorithms and guidelines[3,4] currently available encourage individual institutions to formulate methods based upon the literature in the field of perioperative sleep medicine.

**Conclusion**: Patient safety and cost-effectiveness can work hand-in-hand to provide the right patient with the right care. We believe the RUTGERS Scoring System can aid that process. We are currently gathering data on all of our perioperative patients at risk for OSA, and what strategies are most effective.

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Figure 1: Disposition of patients who are at risk for Obstructive Sleep Apnea from the Post-Anesthesia Care Unit

Patient with BMI >35 kg/m$^2$

Review preoperative screening for Obstructive Sleep Apnea using STOP/BANG

Score of less than 5

Score of 5 or more

Treat as non-OSA.
Does monitoring reveal apnea, hypopnea, or desaturation episode? *

Treat as potential OSA.
Monitor for one hour beyond standard period in PACU.
Does monitoring reveal apnea, hypopnea, or desaturation episode? *

Yes

No

No

Yes

Relatively lower risk of respiratory episodes beyond the PACU. Assess overall perioperative course. May consider discharge to floor or home.

Re-evaluate patient's co-morbidities, intraoperative surgical and anesthetic events, and reconsider risk status for OSA

Is there an explainable or treatable cause, such as residual anesthetics or muscle relaxant, pain, abnormal blood glucose, volume, electrolyte or acid-base disturbance, temperature abnormality, cardiac or pulmonary event, oversedation, pain/sedation mismatch, etc.?

No

Yes

Continue to monitor and evaluate

Correct the problem and continue to monitor and evaluate

Another episode

No further episodes

Another episode

No further episode

Substantially increased risk for respiratory episodes beyond the PACU. Send to a monitored setting.

RUTGERS Score

≥ 3

< 3

| | | 0 | 1 |
|---|---|---|---|
| R | Respiratory events | Respiratory events diagnosed and corrected in PACU | One unexplained respiratory event within 2 hours in PACU |
| U | Uncontrolled co-morbidities | Adequately controlled co-morbidities, e.g. DM, HTN | Co-morbidities not well-controlled |
| T | ShirT size (neck circumference) | Men ≤ 44 cm, Women ≤ 40 cm | Men > 44 cm, Women > 40 cm |
| G | Gynecoid vs. android fat distribution | Gynecoid/peripheral fat distribution | Android/central fat distribution |
| E | Electrolytes, fluids, blood products | Problems corrected | Problems need correcting |
| R | Regimen for pain | Pain adequately controlled, multimodal regimen | Pain control suboptimal, considerable need for narcotics |
| S | Magnitude of Surgery | Anatomically peripheral surgery, or otherwise not expected to cause significant physiologic/systemic compromise, e.g. appendectomy, herniorrhaphy, breast surgery, distal extremity orthopedics | Substantial anatomic trespass, and/or potential for significant physiologic/systemic compromise, e.g. craniotomy, thoracotomy, laparotomy, orthopedic joint replacement |

Relatively lower risk of respiratory episodes beyond the PACU. Assess overall perioperative course. May consider discharge to floor or home.

* Apnea is defined as complete cessation of breathing for more than 9 seconds. Hypopnea is defined as respiratory rate less than 8 breaths per minute. Desaturation is defined as saturation less than 90% for 30 seconds while on nasal cannula of 4 LPM.

# Identifying Patients at Risk for Respiratory Depression based on STOP-Bang and Minute Ventilation in the PACU

**Presenting Author:** Iwona Bonney, Ph.D., Tufts Medical Center, Boston, MA, USA

**Co-Authors:** Brian Harvey, Ph.D., ¬Respiratory Motion, Inc., Waltham, MA, USA, Farhad Zahedi, M.D., Tufts Medical Center, Boston, MA, USA, Roman Schumann, M.D., Tufts Medical Center, Boston, MA, USA

**Background:** Patients with high STOP-Bang (SB) scores have a high probability of obstructive sleep apnea (OSA) and are considered at greater risk for post-operative respiratory complications. Opioids are commonly used for post-operative pain management but decrease respiratory drive and can cause opioid-induced respiratory depression (OIRD). The best perioperative monitoring for safe care, however, has yet to be determined. Objective respiratory measurements in the recovery room (PACU) may be able to identify patients at increased risk of OIRD prior to discharge to a general hospital floor (GHF).

**General Aim:** A non-invasive Respiratory Volume Monitor (RVM) was used to continuously measure minute ventilation (MV), tidal volume (TV) and respiratory rate (RR) in general surgery patients in the PACU and on the GHF. We evaluated the SB score as a predictor of low minute ventilation events (LMVe) in the PACU and GHF. Furthermore, we assessed whether the occurrence of LMVe near the end of PACU stay can identify patients at risk for OIRD following discharge to the GHF.

**Material and Methods:** Following IRB approval and written informed consent, RVM (ExSpiron 1Xi, Respiratory Motion, Inc., Waltham, MA) data were collected intraoperatively, in the PACU, and on the GHF. MV was expressed as percent of MV predicted (MVPRED), based on patient body surface area and sex. An LMVe was defined as a MV<40%MVPRED for ≥2 min and was the objective measure for respiratory depression in this study. LMVe Rate was the number of LMVes per monitored hour. Patients were stratified by SB Score: Low-SB (SB<5) and High-SB (SB≥5)) and by the number of LMVe in the last 45min prior to PACU discharge: Group A: <1LMVe and Group B: >1LMVe. T-tests were used to compare differences between groups, with p<0.05 considered significant.

**Results:** 119 patients were monitored for 4.0±0.3h in the PACU and 10.5±0.5h on the GHF. Patients with High-SB (n=27) experienced the same LMVe Rate as patients with Low-SB (n=92) in the PACU (0.31LMVe/h vs. 0.35LMVe/h, p=0.81) and GHF (0.34LMVe/h vs. 0.55LMVe/h, p=0.22). Stratifying based on the occurrence of an LMVe before PACU discharge, 105 patients met Group A criteria, while 14 patients were in Group B. Group B patients were significantly taller than Group A patients (p=0.0004), but the two groups had similar weight, BMI, and SB scores (Table 1). The LMVe rate was significantly lower in Group A compared to Group B in both the PACU (1 every 5.2h vs. 1 every 48.2 min) and on the GHF (1 every 4.3h vs. 1 every 39.7min). 70% (n=74) in Group A had no LMVe on the GHF and 98.2% of GHF monitored time for all Group A patients was LMVe-free.

**Conclusions:** Patients at high risk for OSA (High-SB) surprisingly had a similar LMVe Rate as patients with a low risk for OSA (Low-SB). Instead of assessing risk based on SB score, monitoring for LMVes during the 30min prior to anticipated PACU discharge may be a more useful parameter to identify postoperative patients at risk for OIRD on the GHF.

**Table 1.** Patient characteristics and monitoring results. Group A, no LMVe within 45min of PACU discharge. Group B, > 1 LMVe within 45min of PACU discharge. Data in means (SD) for patient characteristics and mean (SEM) for monitoring results. LOM = Length of Monitoring.

| | | Population | Group A | Group B | P-Value |
|---|---|---|---|---|---|
| | N | 119 | 105 | 14 | 0 |
| | Males/Females | 18/111 | 10/95 | 8/6 | 0 |
| | Weight, kg | 100.9 (30.1) | 101.2 (29.6) | 98.8 (34.5) | 0.776 |
| | Height, cm | 164.9 (9.5) | 163.8 (8.6) | 173.2 (11.8) | 0.0004 |
| | BMI, kg/m$^2$ | 37.0 (10.0) | 37.6 (10.0) | 32.4 (9.3) | 0.070 |
| | STOP-Bang score | 3.3 (1.7) | 3.2 (1.6) | 3.9 (2.0) | 0.17 |
| PACU | LOM, hours | 4.0 (0.3) | 3.9 (0.3) | 4.5 (0.9) | 0.452 |
| | Percent MV$_{PRED}$ | 109.8 (4.6) | 114.2 (5.0) | 76.8 (8.1) | 0.0083 |
| | LMVe Per Hour | 0.32 (0.07) | 0.19 (0.05) | 1.24 (0.37) | <0.00001 |
| | LMVe Duration, minutes | 4.0 (0.1) | 3.8 (0.1) | 4.3 (0.5) | 0.40 |
| | % Time without LMVe | 97.7 (0.5) | 98.6 (0.4) | 91.5 (2.9) | <0.00001 |
| GHF | LOM, hours | 10.5 (0.5) | 10.4 (0.5) | 11.0 (1.5) | 0.70 |
| | Percent MV$_{PRED}$ | 115.2 (5.2) | 121.7 (5.6) | 65.4 (4.8) | 0.0006 |
| | LMVe Per Hour | 0.38 (0.07) | 0.23 (0.05) | 1.51 (0.38) | <0.00001 |
| | LMVe Duration, minutes | 4.3 (0.1) | 4.0 (0.1) | 5.0 (0.4) | 0.014 |
| | % Time without LMVe | 96.8 (0.7) | 98.2 (0.4) | 85.7 (3.9) | <0.00001 |

**Experience from a Yale Pilot Program on Inpatient Perioperative Screening and Management of Obstructive Sleep Apnea**

**Presenting Author:** Vivian Asare, MD, Yale University

**Co-Authors:** Christine Won, MD, MSc, Yale University, Jean Charchaflieh, MD, MPH, DrPH, Yale University, Jill Zafar, MD, Yale University

**Introduction:** The peri-operative period poses risk to the patient with known or suspected obstructive sleep apnea (OSA) due to many factors. A pilot program to help minimize OSA-related perioperative complications was initiated at Yale New Haven Hospital Total Joint Arthroplasty (TJA) and Spine unit from February to June, 2017.

**Methods:** Patients with known OSA were triaged to a standardized protocol employing perioperative risk mitigation measures, extended monitoring in the Post -anesthesia care unit (PACU), postoperative monitoring, and appropriate patient and family education on discharge. Patients with unknown OSA status underwent a risk stratification algorithm, with STOP-BANG scores $\geq 5$ considered high risk for OSA. These patients were risk stratified in six phases of care: pre-surgical, pre-operative, intra-operative, PACU, inpatient floor post-operative, and home discharge. In the pre-surgical phase of care, patients with OSA or high risk of OSA were flagged in our electronic record. Patients with known OSA that were compliant on PAP therapy were instructed to bring their PAP device on day of surgery. Early screening allowed for referrals to Sleep Medicine for further testing. Pre-operative assessment of OSA status and risk stratification allowed for risk mitigation measures in the intra-operative phase. The PACU phase of care involved direct sign off from the intra-operative team to the PACU staff to flag OSA status and plan for post PACU monitoring. During inpatient floor postoperative phase of care, oxygen saturations and levels of consciousness were monitored and a standardized protocol for escalation of care was followed by nurses (see below criteria). Lastly, the home discharge plan of care took effect when the patient met all criteria for discharge (see below criteria). Patients and families received education on risks of OSA and respiratory effects of sedating pain medications. Sleep Medicine outpatient referrals were recommended at that time.

**Results:** From May 1, 2017 to June 8, 2017, 150 patients underwent joint surgery at Yale New Haven Hospital TJA unit, and 52% were screened with the STOP-BANG questionnaire. Some barriers to screening included incomplete questionnaires and documentation redundancy. 13% of patients screened were found to be high risk for OSA, and 18% had known OSA prior to surgery, making for an overall prevalence of 43.8% in this patient population. These patients were appropriately risk stratified and had extended PACU and inpatient floor monitoring as per our Perioperative OSA algorithm. Pilot limitations encountered include, incomplete STOP-BANG scores and neck circumference measurements, and variations of documentation of OSA status.

**Conclusion:** A risk stratification peri-operative management pathway for OSA is feasible in a large hospital orthopedics program. One major limitation was screening adherence. The high prevalence of known or suspected OSA in this population imposed a need for greater hospital resources per our protocol. However, the cost of increased resources during the peri-operative period may be offset by the reduction in peri-operative complications related to unrecognized OSA. More data regarding the efficacy of this protocol in preventing peri-operative complications will be gathered.

Escalation of Care Criteria:

1)       Continuous electronic monitoring of oxygenation by pulse oximetry (SpO2)
2)       Supplemental O2 as needed to maintain SpO2> 95%
3)       Hourly monitoring of consciousness by visual observation
4)       Patients compliant on CPAP with known OSA receive their home settings
5)       Floor nurse escalates care if within one hour, there are three events of either desaturation to <90% or decreased level of consciousness


Discharge Criteria:

The following are met after monitoring in a restful, un-stimulated setting for 30 minutes:

1) Oxygenation (SpO2 not less than 2 points than pre-operative baseline)
2) Ventilation (RR> or equal to 10 and un-obstructed pattern), while the patient is breathing spontaneously, on room air (or baseline oxygen supplement)

**Factors Affecting Rates of Respiratory Depression in Patients Undergoing Eye Surgery**

**Presenting Author:** Kaitlyn A Brennan DO, MPH

**Co-Authors:** Kyle M Russell, RN; Juraj Sprung, MD, PhD; Toby N Weingarten MD; David P Martin MD, PhD

**Background:** Ophthalmologic procedures are commonly performed ambulatory surgeries. Though these procedures are generally considered safe, the appropriateness of patients with obstructive sleep apnea (OSA) undergoing ambulatory surgery remains controversial.[1] Our institution has a unique system of detecting episodes of respiratory depression during Phase I anesthesia recovery, and episodes of respiratory episodes have been linked to later adverse pulmonary outcomes in nonambulatory surgical patients.[2] The aim of this study is to determine the incidence and factors associated with respiratory depression during anesthetic recovery in patients undergoing cataract procedures.

**Materials and Methods:** IRB approval (IRB 17-001771) was provided by Mayo Clinic, Rochester, MN, USA on 3/15/2017 for this retrospective study. Patients undergoing ophthalmologic procedures from 2010 – 2016 in our ambulatory surgical center underwent in depth chart review for patient comorbidities, anesthetic factors, and episodes of respiratory depression (episodes of hypoventilation, apnea, oxyhemoglobin desaturations <90%, or "pain sedation mismatch" [moderate to severe pain in the setting of mild to deep sedation]).[2] Analyses were performed to identify risk associated risk factors with episodes of respiratory depression.

**Results:** Out of 20,216 patients, 449 had episodes of respiratory depression, (22 cases [95%CI 20 – 24] per 1,000 procedures) were observed during anesthesia recovery. Patient factors such as body mass index, OSA or disease burden (assessed by the Charlson Comorbidity Index score) were not associated with respiratory depression. Associated factors were procedural duration odds ratio 1.04 (95% CI 1.01, 1.08) per minute, general anesthetic compared to sedation 2.38 (1.59, 3.62), and use of either fentanyl 2.13 (1.44, 3.10) or propofol 3.31 (2.25, 4.09) during the procedure. Use of midazolam was not associated with respiratory depression, 0.79 (0.52, 1.16). Patients who had respiratory depressive episodes had longer anesthetic recoveries, median recovery of 55 [36, 95] minutes versus 36 [28, 47] minutes, P<0.001.

**Discussion and Conclusion:** Patient factors, especially OSA, were not associated with increased risk for episodes of respiratory depression during anesthetic recovery. However, general anesthesia and the use of fentanyl or propofol were associated with increased risk. These findings suggest that patients with sleep disordered breathing can have an uncomplicated anesthetic recovery following ambulatory ophthalmologic procedures. However, this study does not assess for complications that may occur following dismissal from the ambulatory procedural center.

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# Development of a Perioperative Pathway for Adult Patients with (Suspected) Obstructive Sleep Apnea to Alleviate Intensive Care Unit Resource Utilization and Maximize Patient Safety

**Presenting Author:** Mathias Opperer, Department of Anesthesiology, perioperative Medicine and Intensive Care Medicine, Paracelsus Medical University Salzburg, Austria

**Co-Authors:** Anja Claudine Nawratil, Bernhard Leiner, Andreas Koköfer, Peter Gerner, Department of Anesthesiology, perioperative Medicine and Intensive Care Medicine, Paracelsus Medical University Salzburg, Austria

**Background:** Patients presenting for surgery frequently carry the risk of undiagnosed obstructive sleep apnea[1], which in turn can be linked to perioperative complications[2] and increased intensive care unit utilization[3]. Starting with March 2017 patients at our departmental preoperative clinic were screened for obstructive sleep apnea using the STOP-BANG questionnaire. Lacking a clinical decision support algorithm and oximetry monitoring capabilities on our surgical wards this led to an increase in intensive care unit allocation, postponed or cancelled procedures and growing discontent of patients, surgical partners and anesthesiologists.

**General Aim:** The objective of this project was to alleviate stress on intensive care unit resource utilization, while identifying patients at perioperative risk and providing guidance for perioperative clinicians. We aimed to give departmental staff a clear path to navigate and limit individual liability as well as unwarranted admittance to intensive care units.

**Materials and Methods:** After extensive literature review and identification of departmental requirements, selected members of the Department of Anesthesiology proposed an initial concept for perioperative handling of OSA patients based on the practice guidelines of the American Society of Anesthesiologists[4] and the SASM Guidelines on Preoperative Screening and Assessment of Adult Patients With Obstructive Sleep Apnea[5]. Based on this proposal and after incorporation of expert opinion a departmental consensus was achieved and visualized (Fig. 1).

**Results:** The preoperative evaluation includes the possibility of preoperative referral to a sleep clinic in elective cases or portable sleep testing the night before surgery for semi-elective cases. During intraoperative management, patients will be closely monitored and care optimized according to current expert consensus. A 9-item scoring system closely modeled after the proposed scoring system of the ASA practice guidelines was implemented. One major adaptation is the inclusion of STOP-BANG scores in OSA severity estimation, facilitating preoperative planning for patients suspected of OSA by our screening program. Overall the scoring system was simplified and adapted to our regional needs. Postoperative patient evaluation and transfer is based upon this score with the PACU acting as a gatekeeper to further clear or mark patients of intermediate perioperative risk for intensive care ward admittance.

**Discussion:** As current practice guidelines fail to provide specific recommendations on postoperative monitoring duration and clinical pathway generation this concept constitutes our expert opinion of feasible best clinical care for patients with OSA without overburdening intensive care units. This pathway depicts a solution for a highly specific setting, but might be of interest to similar situated hospitals and help in hypothesis generation for future studies. While initial departmental feedback is encouraging, formal evaluation of patient outcomes and its impact on resource utilization is yet to come.

**Conclusion:** Development, implementation and visualization of a perioperative pathway for patients with (suspected) obstructive sleep apnea can help streamline patient care and acceptance of perioperative screening programs.

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## Perioperative pathway for adult patients with obstructive sleep apnea (OSA)

### pre-operative

AHI > 5 plus symptoms
AHI ≥ 15 → OSA diagnosed

STOP-BANG ≥ 5 → OSA suspected

STOP-BANG < 5 → OSA minimal risk

OSA diagnosed → no therapy / CPAP

no therapy → urgent procedure / elective procedure (>1 month)

CPAP → consider referral

consider referral → elective procedure (>1 month) / urgent procedure

consider preoperative testing

**Perioperative OSA Risk Score (0-9)**

OSA Severity (0-3)
0 - no OSA/risk (AHI 0 to 5, SB < 5)
1 - mild OSA/risk (AHI 6 to 20, SB ≥ 5)
2 - moderate OSA/risk (AHI 21 to 40, SB ≥ 7)
3 - severe OSA/risk (AHI > 40, SB ≥ 7 & symptoms)

Procedure/anesthesia invasiveness (0-3)
0 - no sedation/Standby
1 - superficial to moderate sedation
2 - deep sedation/low risk procedure with GA
3 - high risk procedure (airway/bariatric) with GA

Postoperative opioids (0-3)
0 - no postoperative opioids
1 - peroral opioids in low dosage
2 - i.v. opioids in low dosage
3 - i.v. and oral opioids in high dosage

### intra-operative

General anesthesia/ deep sedation → postoperative i.v. opioids → bariatric / airway surgery → **Risk Score > 6**

Regional anesthesia/ moderate sedation → postoperative oral opioids → intermediate invasive procedure → **Risk Score 4 - 6**

Standby anesthesia/ no sedation → no postoperative opioids → minimal invasive procedure → **Risk Score 0 - 3**

Risk Score > 6 → high perioperative risk
Risk Score 4 - 6 → intermediate perioperative risk
Risk Score 0 - 3 → minimal perioperative risk

⚠ **Beware**

Anticipate difficult airway/ventilation
Avoid long-acting opioids/sedatives/relaxants
Use long acting regional anesthesia techniques

Risk Score 0-3 suitable for ambulatory surgery
Mind the cause (central, obesity-hypoventilation,...)

Possibly transfer severe OSA and airway procedures to ICU for NIV/weaning

### post-operative

high perioperative risk → CPAP not possible / CPAP possible

PACU monitor + 1 hour

Patient does not meet transfer criteria → Intermediate Care Ward
Patient meets transfer criteria → Non-monitored Ward

**Transfer criteria to non-monitored ward**

☐ no relevant desaturation events during PACU stay
☐ no unexpected analgesic requirements
☐ good tolerance/acceptance of CPAP where possible
☐ supplemental O2 insufflation ≤ 5l/min

⚠ **Beware**

Patient positioning (lateral or elevated)
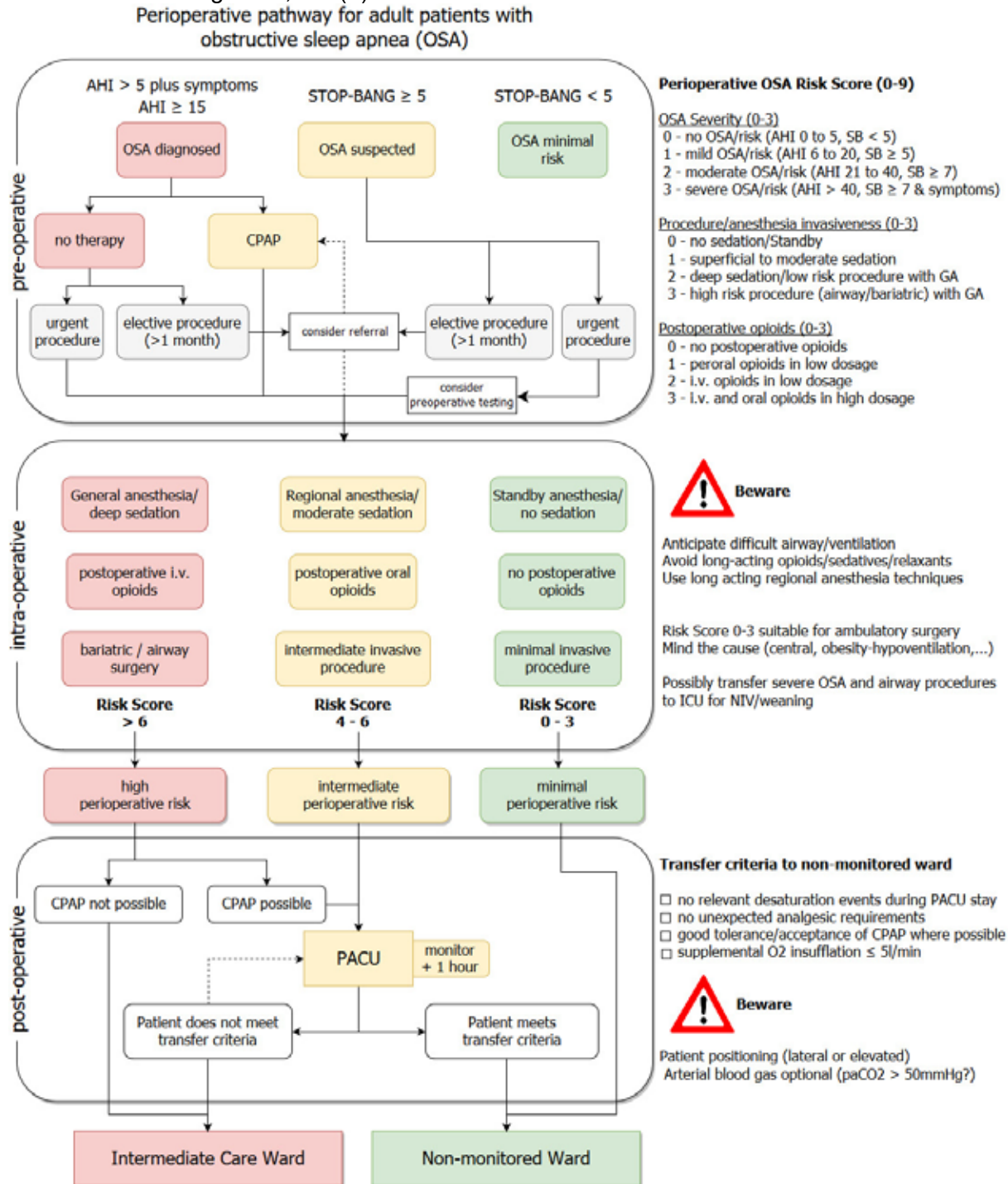Arterial blood gas optional (paCO2 > 50mmHg?)

Fig. 1 Visualization of the perioperative pathway for adult patients with obstructive sleep apnea adapted from the practice guidelines of the American Society of Anesthesiologists[4] for use at the University Hospital of Salzburg (translated into English). AHI = apnea/hypopnea index, SB = STOP-BANG Score, GA = general anesthesia.

# Gabapentinoid Therapies and Risk for Postoperative Naloxone Administration

**Presenting Author:** Carmelina Gurrieri, M.D., Mayo Clinic, Rochester, Minnesota

**Co-Authors:** Atousa Delijou, M.D, Mayo Clinic, Rochester, Minnesota
Juraj Sprung, M.D., Ph.D, Mayo Clinic, Rochester, Minnesota, Toby N. Weingarten, M.D., Mayo Clinic, Rochester, Minnesota

**Introduction**: Single preoperative gabapentinoid (gabapentin and pregabalin) administration has been associated with respiratory depression during anesthesia recovery. (1)  In this study we assess for associations between chronic (home) use, single preoperative administration, and postoperative administration of gabapentinoid and risk for postoperative naloxone administration (as a marker for severe over-sedation or respiratory depression).

**Material and Methods**: From 2011 to 2016 we identified patients undergoing general anesthesia, discharged to standard postoperative wards and administered naloxone within 48 hours of surgery.  These patients were matched 2:1 on age, sex, and type of procedure.  Patient and perioperative characteristics were abstracted and compared to assess for risk for naloxone administration.

**Results**: One hundred twenty-eight patients were administered postoperative naloxone after anesthesia recovery (incidence of 1.2 [95% CI 1.0, 1.4] *per* 1,000 general anesthetics). Chronic/home and postoperative gabapentinoid use, but not preoperative administration were higher among cases.  Multivariable analysis detected significant interactions between chronic and postoperative use of gabapentinoids, where continuation of chronic gabapentinoid medications into the postoperative period was associated with naloxone administration (odds ratio 6.30, 95% CI 2.38, 16.66, P=0.001).  Obstructive sleep apnea and preoperative disability were also associated with postoperative naloxone administration.  Patients who were administered naloxone had longer hospital stays and rates of postoperative delirium.

**Discussion**: Chronic gabapentinoid therapy is highly associated with naloxone administration following discharge from postanesthesia care areas. The reason for this observation is not immediately clear, however, there is a possibility that these medications may potentiate the respiratory depressant effects of anesthesia and opioids as it has been observed in previous studies. (2,3)

**Conclusion**: Continuation of chronic gabapentinoid medications into the postoperative period is highly associated with the need for naloxone administration to reverse over-sedation or respiratory depression. Such patients requiring this therapy warrant high levels of postoperative monitoring.

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