

# Postoperative Opioid-induced Respiratory Depression

## A Closed Claims Analysis

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### ABSTRACT

**Background:** Postoperative opioid-induced respiratory depression (RD) is a significant cause of death and brain damage in the perioperative period. The authors examined anesthesia closed malpractice claims associated with RD to determine whether patterns of injuries could guide preventative strategies.

**Methods:** From the Anesthesia Closed Claims Project database of 9,799 claims, three authors reviewed 357 acute pain claims that occurred between 1990 and 2009 for the likelihood of RD using literature-based criteria. Previously cited patient risk factors for RD, clinical management, nursing assessments, and timing of events were abstracted from claim narratives to identify recurrent patterns.

**Results:** RD was judged as possible, probable, or definite in 92 claims ( $\kappa = 0.690$ ) of which 77% resulted in severe brain damage or death. The vast majority of RD events (88%) occurred within 24 h of surgery, and 97% were judged as preventable with better monitoring and response. Contributing and potentially actionable factors included multiple prescribers (33%), concurrent administration of nonopioid sedating medications (34%), and inadequate nursing assessments or response (31%). The time between the last nursing check and the discovery of a patient with RD was within 2 h in 42% and within 15 min in 16% of claims. Somnolence was noted in 62% of patients before the event.

**Conclusions:** This claims review supports a growing consensus that opioid-related adverse events are multifactorial and potentially preventable with improvements in assessment of sedation level, monitoring of oxygenation and ventilation, and early response and intervention, particularly within the first 24 h postoperatively. (**ANESTHESIOLOGY 2015; 122:659-65**)

POSTOPERATIVE opioid-induced respiratory depression (RD)<sup>1</sup> has gained increasing attention as a potentially preventable cause of death and brain damage after surgery. Cashman and Dolin<sup>2</sup> performed a meta-analysis of 165 articles on postoperative pain management involving almost 20,000 patients who had thoracic, abdominal, major gynecological, or major orthopedic surgery using a single postoperative analgesic technique with observation for adverse events for at least 24 h postoperatively. Based on their analysis, the authors reported incidence of RD varies from 0.1 to 37%,<sup>2</sup> depending on the route of administration of the opioid, the type of opioid, the definition and method of monitoring RD, and the prospective versus retrospective nature of the study. The lowest estimates were reported when naloxone administration was used as the criterion for RD, followed sequentially by higher estimates based on respiratory rate, hypercarbia, and oxygen desaturation.<sup>2</sup> In The Joint Commission's review of opioid-related events from

#### What We Already Know about This Topic

- Postoperative opioid-related respiratory depression is an important cause of iatrogenic injury in the perioperative period
- Risk factors for this injury are numerous and not applicable to all patients who develop respiratory depression

#### What This Article Tells Us That Is New

- In a review of 357 acute pain claims from the Anesthesia Closed Claims Project database, 92 cases involved likely opioid-related respiratory depression
- The vast majority of these injuries occurred within 24 h of surgery and 97% were judged as preventable with better monitoring and response

their Sentinel Event Database from 2004 to 2011, wrong dose medication errors were present in half of the events, improper monitoring occurred in almost one third, and other factors related to medication dosing and interactions

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were present in 11%.\* In August 2012, these findings prompted The Joint Commission Sentinel Event Alert Issue 49 regarding the safe use of opioids in hospitals.\* The Alert recommended implementing policies and procedures to minimize the risk of RD, including identification of patients at high risk for opioid-induced RD; use of alternative non-opioid analgesic regimens; improved assessment of sedation level, ventilation, and oxygenation in patients receiving opioids; improved education of healthcare providers involved in prescribing opioids and/or monitoring for opioid-induced RD; and quality improvement processes for opioid-related incidents.\*

The Joint Commission, the Institute for Safe Medication Practices,† and the Anesthesia Patient Safety Foundation‡ suggest that patient harm associated with opioid-induced RD is preventable. However, the recommended intervention(s) to reduce RD and prevent poor outcomes are based largely on consensus opinion because data regarding their efficacy are lacking due to the rarity of serious complications. Careful review of rare sentinel events is one method to identify causal factors that if modified or attended to could prevent undesirable outcomes. With these goals in mind, we analyzed the Anesthesia Closed Claims Project Database to identify clinical characteristics and management factors in malpractice claims associated with RD. We hypothesized that trends identified in medical malpractice claims could guide or reinforce strategies to reduce the potential for opioid-related adverse outcomes.

## Materials and Methods

The Anesthesia Closed Claims Project database is a structured collection of closed anesthesia malpractice claims that has been described in detail elsewhere.<sup>3,4</sup> Briefly, on-site anesthesiologist reviewers abstracted data from closed anesthesia malpractice claims onto detailed data collection instruments at participating professional liability companies across the United States. The panel of 22 companies (at the time of this study) insured approximately one third of practicing anesthesiologists in the United States. Information was collected from medical records, consultant evaluations, expert witness reports, claims manager summaries, and legal summaries. Data collected included patient demographics, type of surgery, details regarding the anesthesia care, patient outcomes,

and legal outcomes. The on-site reviewers evaluated the standard of care, outcome, severity of injury, cause of injury (*i.e.*, damaging event), and preventability of the injury. In addition, the on-site reviewers summarized the claim, including the sequence of events and causes of injury. The Closed Claims Project Investigator Committee reviewed the claims, and any disagreements in assessments were resolved by an additional Committee member.

For this study, we examined the Anesthesia Closed Claims Project database comprising 9,799 claims. Inclusion criteria were claims associated with acute pain management in which the damaging event occurred between 1990 and 2009 ( $n = 357$ ). A two-stage screening process was used to identify RD-related claims. The first stage excluded claims based on damaging events and injuries that were clearly unrelated to RD, such as regional block complications, surgical complications, pneumothorax, and nerve injury. The remaining 138 claims were then comprehensively reviewed by three author anesthesiologists (L.A.L., R.A.C., K.B.D.) for the likelihood of RD.

We used predefined, literature-based<sup>1,2</sup> criteria to identify RD. Criteria for *definitive* RD were as follows: (1) patient received naloxone and showed evidence of reversal of RD, or (2) other clear and objective signs of RD or opioid toxicity, for example, patient with a constellation of clinical signs such as oversedation, respiratory arrest, and need for resuscitation. Criteria for *probable* RD were as follows: (1) respiratory rate less than 8/min, (2) somnolence, (3)  $SpO_2$  less than 90% in the absence of abnormal baseline  $SpO_2$ , (4) pinpoint pupils, (5) administration of high doses of opioids in opioid-naïve patient, or (6) qualitative observation of RD (*e.g.*, snoring, airway obstruction, or cyanosis) that required intervention (*e.g.*, jaw lift, positive pressure mask ventilation, or intubation). The criterion for *possible* RD was a patient found in cardiopulmonary arrest *without* another identified cause (*e.g.*, pulmonary embolism or neuraxial cardiac arrest) *and with* a presumed risk for RD (*e.g.*, obese patient receiving significant amounts of opioids, history of snoring, loud breathing, or somnolence).

### Definition of Variables

The severity of injury score assigned by the on-site reviewer used the National Association of Insurance Commissioners' 10-point scale, which ranges from 0 (no apparent injury) to 9 (death).<sup>5</sup> This scale was collapsed into three categories for this analysis: death (score = 9); permanent disabling injuries (score = 6–8); and temporary or minor injuries (score = 0–5). Appropriateness of anesthesia care was assessed by the initial on-site reviewer as appropriate (based on reasonable or prudent practice at the time of the event), substandard, or impossible to judge. The reliability of these evaluations was judged to be acceptable.<sup>6</sup>

Modalities by which opioids were administered for pain control were classified as neuraxial (epidural or spinal), patient-controlled analgesia (PCA), or other (including

\* The Joint Commission Sentinel Event Alert Issue 49: Safe Use of Opioids in Hospitals. August 8, 2012. Available at: [http://www.jointcommission.org/assets/1/18/SEA\\_49\\_opioids\\_8\\_2\\_12\\_final.pdf](http://www.jointcommission.org/assets/1/18/SEA_49_opioids_8_2_12_final.pdf). Accessed August 7, 2014.

† Institute for Safe Medication Practices. High alert medication feature: Reducing patient harm from opiates. ISMP Medication Safety Alert! February 22, 2007. Available at <http://www.ismp.org/newsletters/acutecare/articles/20070222.asp>. Accessed August 7, 2014.

‡ Stoelting RK and Overdyk FJ for the Anesthesia Patient Safety Foundation: Conclusions and Recommendations from June 8, 2011, Conference on Electronic Monitoring Strategies (Essential Electronic Monitoring Strategies to Detect Clinically Significant Drug-induced Respiratory Depression in the Postoperative Period). Available at: <http://apsf.org/initiatives.php?id=10>. Accessed August 7, 2014.

intramuscular injection, non-PCA intravenous therapy, or oral routes). Data were also collected on type of opioid, coadministration of nonopioid sedating medications (*e.g.*, benzodiazepines, hypnotics, butyrophenones, phenothiazines, and antihistamines), and whether or not patients were receiving supplemental oxygen immediately before the RD event. The opioid dose was defined as excessive if the primary damaging event in the database was classified as a wrong dose.

The three anesthesiologists independently identified the presence of the following potential contributory factors for RD: preoperative diagnosis of obstructive sleep apnea (OSA), high risk for OSA, more than one opioid modality, more than one physician prescribing opioids or nonopioid sedating medications for the patient during the episode of care, history of chronic use of opioids, and the timing (in minutes) between the last nursing check and the RD event. High risk for OSA was defined as the presence of three or more criteria from the STOP-Bang screening tool.<sup>7</sup> Risk factors assessed were male gender, patient age greater than or equal to 50 yr, body mass index greater than 35 kg/m<sup>2</sup>, and hypertension. Other risk factors from STOP-Bang were not available. Obesity was defined as either a body mass index of 30 kg/m<sup>2</sup> or greater, or a designation of the patient as obese by the on-site closed claims reviewer. The authors also evaluated the postoperative timing of the RD event, the adequacy of postoperative nursing checks (based on symptoms assessed and response to symptoms), and whether better monitoring would have possibly, probably, or definitely prevented the injury. An event was assessed as preventable by better monitoring if, regardless of whether it was standard of care at the time, the better use of monitoring devices or the use of additional monitors might have prevented the injury.

### Statistical Analysis

Interrater reliability of author judgments of RD criteria, nursing assessments, and preventability by respiratory monitoring was assessed by the kappa ( $\kappa$ ) statistic. The  $\kappa$  statistic measures the level of agreement that exceeds agreement by chance.  $\kappa$  of 0.40 is considered acceptable, and 0.75 or higher is generally accepted as excellent agreement beyond chance. Payments made to the plaintiff were adjusted to 2012 dollar amounts with the Consumer Price Index<sup>§</sup> and are reported as median and interquartile range because they were not normally distributed. All statistical analysis used SPSS 19 for Windows (IBM Corporation, Armonk, NY).

## Results

### Patient and Case Characteristics

Ninety-two claims met inclusion criteria for possible (27%), probable (52%), or definite (21%) RD (81% agreement,  $\kappa = 0.690$ ). The patients were mostly middle aged, obese,

**Table 1.** Characteristics of Respiratory Depression Claims\*

Characteristic	n (%)
Female (n = 91)	52 (57)
Obese (n = 71)	47 (66)
ASA physical status 1–2 (n = 87)	55 (63)
Age (mean $\pm$ SD), yr, (n = 85)	50 $\pm$ 17.7
Patient $\geq$ 50 yr old (n = 85)	37 (44)
History of chronic opioid use	7 (8)
OSA diagnosis	15 (16)
High risk of OSA†	8 (9)
Lower extremity surgery	38 (41)

\*n = 92 unless otherwise stated. Cases with missing data excluded. †High risk defined by the STOP-Bang questionnaire as presence of 3 or more OSA risk factors. Risk factors assessed were male gender, patient age  $\geq$ 50 yr, body mass index  $>$ 35 kg/m<sup>2</sup>, and hypertension. Other risk factors from STOP-Bang were not available.

ASA = American Society of Anesthesiologists; OSA = obstructive sleep apnea.

and American Society of Anesthesiologists physical status 1 and 2, with a slightly higher proportion of women than men (table 1). One quarter of the patients were either diagnosed with OSA preoperatively (16%) or were at high risk for OSA (9%, table 1). Forty-one percentage of patients underwent a lower extremity orthopedic procedure, primarily knee or hip replacement (table 1). Most (62%) of these lower extremity procedures occurred in the 1990s.

### Medication Factors

PCA (53%) and neuraxial analgesia (39%) were the most common modes of pain control. Neuraxial administration of opioids included epidural in 32 claims and subarachnoid in four. There were no claims associated with peripheral nerve blocks or catheters. Nearly half of the patients received an opioid by more than one modality, and nearly half had a continuous opioid infusion at the time of the event (table 2). Table 3 presents a summary of the analgesics given and modalities of administration (including continuous infusions). Morphine and fentanyl were the most common opioids administered

**Table 2.** Medication Factors Associated with Respiratory Depression

	n (%)
Routes of Opioid Therapy	
PCA only	17 (18)
Neuraxial only	16 (17)
Other only*	16 (17)
Multimodal†	43 (47)
Continuous infusion of opioids	42 (46)
Interaction of opioid and nonopioid sedative medications	31 (34)
More than one physician prescribing (n = 91)	30 (33)
Excessive opioid dose	15 (16)

n = 92 unless otherwise stated (cases with missing data excluded).

\*Other single modality patients included 11 patients with non-PCA intravenous, 1 with oral only, and 1 with transdermal. †Multimodal included PCA and other (n = 23), neuraxial and other (n = 11), neuraxial and PCA (n = 5), neuraxial, PCA, and other (n = 4).

PCA = patient-controlled analgesia.

§ Bureau of Labor Statistics, U.S. Department of Labor. Consumer Price Index inflation calculator. Available at: <http://www.bls.gov/data/home.htm>. Accessed January 2, 2013.

**Table 3.** Postoperative Opioids by Routes of Administration\*

Opioid	All Claims (n = 92)	Neuraxial† (n = 36)	PCA (n = 49)	IV bolus (n = 49)
	n (%)	n (%)	n (%)	n (%)
Morphine	59 (64)	17 (47)	33 (67)	29 (59)
Fentanyl	23 (25)	19 (53)	2 (4)	5 (10)
Meperidine	22 (24)	1 (3)	6 (12)	14 (29)
Hydromorphone	23 (25)	0 (0)	14 (29)	13 (27)
Other‡	11 (12)	4 (12)	1 (2)	1 (2)
Continuous infusion of opioids				
Yes §		27 (75)	16 (33)	
No		9 (25)	4 (8)	
Unknown		0 (0)	29 (59)	

\*Cases with missing data excluded. Total claims = 92. Percentages are based on the claims for that route (by column). The totals may sum to greater than 100% because multiple opioids were given to some patients. The sum of specific opioids over different routes of administration may differ from the total due to administration of the same opioid by different routes in some patients, including other routes not shown. †Epidural = 32; spinal = 4. ‡Other neuraxial (butorphanol n = 2, sufentanil n = 1, unknown n = 1), other PCA (unknown n = 1), IV bolus (unknown n = 1). §One patient had continuous infusion of both neuraxial and PCA. IV = intravenous; PCA = patient-controlled analgesia.

via the neuraxial route (table 3). Nonopioid sedating medications were used postoperatively and potentially interacted with opioids in over a third (n = 31) of RD cases (table 2), the most common of which were phenothiazines and benzodiazepines. More than one physician was prescribing opioids and/or other sedating medications for the patients in one third of all RD events (table 2). Excessive doses were prescribed in a minority of the cases (16%, table 2).

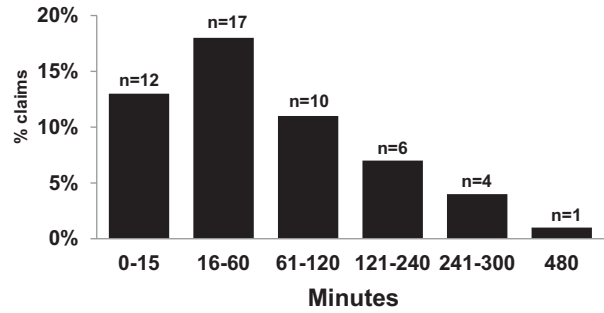
**Timing, Monitoring, and Nursing Assessment Factors**

The majority (88%) of RD events occurred within 24 h of the surgical procedure (table 4). At least 12 (13%) of the RD events occurred within 2 h after discharge from the recovery room to the floor. Respiratory monitors were not in use at

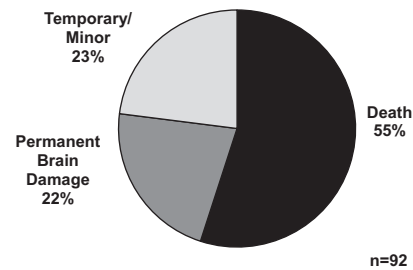
**Table 4.** Timing, Monitoring, and Nursing Assessments\*

	n (%)
Timing of RD event	
Day of surgery	81 (88)
Within 2 h of arrival on floor†	12 (13)
Monitoring	
Pulse oximetry‡	30 (33)
No respiratory monitoring	53 (58)
Supplemental oxygen in use before event	14 (15)
Nursing assessments and patient status	
Patient experienced heavy snoring before event§	14 (15)
Patient experienced somnolence before event (n = 91)	56 (62)
Inadequate nursing checks (n = 89)	28 (31)

\*n = 92 unless otherwise stated. Cases with missing data excluded. †The RD event probably occurred within 2 h in another four cases based on the description of events, but specific time stamps were unavailable. ‡All non-telemetric. §Thirteen of the 14 patients also experienced somnolence. RD = respiratory depression.



**Fig. 1.** Time between last nursing check and discovery of opioid-induced respiratory depression (RD). Claims with unknown timing (n = 39) and not applicable (at home, n = 3) not shown.



**Fig. 2.** Severity of injury in opioid-induced respiratory depression (RD) claims. More than half (55%) of the RD claims were associated with death, and approximately one quarter (22%) were associated with severe brain damage.

the time of the event for more than half of the patients (n = 53), while pulse oximetry was present in only 30 cases (all nontelemetric, table 4).

Nurses discovered the RD event in 37% of claims, followed by family or friends in 14%, other hospital staff in 3%, and the remainder unknown. The elapsed time between the last nursing assessment and the discovery of RD was within 2 h in 39 cases (42%) and within 15 min in 12 of these cases (fig. 1). Contributing factors in these 12 cases were identified as drug interactions with nonopioid sedative medications (n = 6), OSA diagnosis (n = 4), high risk for OSA (n = 2), medication errors with opioid overdose (n = 2), PCA administration by a relative (n = 1), and upper airway obstruction from mononucleosis (n = 1) and posttonsillectomy (n = 1). More than 60% of all RD patients had been described as somnolent with or without snoring before the RD event (table 4), including 9 of the 12 patients whose event occurred within 15 min of an assessment. Nursing checks were judged as inadequate for 31% of claims (79% agreement,  $\kappa = 0.533$ ) based on summary statements concerning their quality (e.g., lack of vital signs or inattention to clinical signs such as somnolence and/or oxygen desaturation) or frequency (e.g., lapsed time since last check). An example of inadequate quality of nursing checks was a case in which an obese male in his 40s was noted on the first postoperative morning in a general nursing assessment as sleepy, slow to arouse, and snoring loudly. His pulse oximeter read 49% on room air, and his oxygen

**Table 5.** Assessment of Care and Liability in Respiratory Depression Claims\*

	n (%)
Appropriateness of anesthesia care (n = 90)	
Less than appropriate	36 (40)
Appropriate	54 (60)
Would better monitoring have prevented the complication?	
Probably	43 (47)
Possibly	46 (50)
No	3 (3)
Payment made (n = 88)	40 (45)
Median payment (n = 40, 2012 dollars)	\$216,750
Interquartile range	\$49,693–\$604,360

\*n = 92 unless otherwise stated. Cases with missing data excluded.

was replaced immediately with an improvement in his pulse oximeter reading to 93%. The patient was described as being “without complaints.” The nurse then left to complete her additional rounds without contacting or speaking to a physician. The patient was found apneic 28 min later, and a full code was called. The patient died a few days later from an anoxic brain injury.

### Injury and Liability

More than half of the patients who experienced RD died, and another 22% had severe brain damage (fig. 2). The appropriateness of anesthesia care was judged by the on-site reviewer as less than appropriate in 40% of the claims (table 5). Almost all the claims (97%) were judged as probably (n = 43) or possibly (n = 46) preventable by better monitoring (62% agreement,  $\kappa = 0.279$  due to high level of agreement). Examples of claims and assessments of preventability of RD with better monitoring are provided in table 6. Payment to the plaintiff was made in 45% of claims, with a median payment of \$216,750 (table 5).

### Discussion

The majority of RD events in this national database shared three basic features: they resulted in death or severe brain damage, they occurred within the first 24 h of surgery, and they were preventable. These findings are consistent with single institution studies, demonstrating that the most vulnerable period for patients occurs in the initial 24 h postoperatively<sup>8–10</sup> when the effects of general anesthesia, optimization of opioid analgesics, sedating antiemetics, and sleep deprivation converge. Chung *et al.*<sup>11</sup> have shown that disturbance of sleep architecture is greatest on the first postoperative night in both OSA and non-OSA patients, with a significant decrease in sleep efficiency, rapid eye movement sleep, and slow-wave sleep compared with a preoperative baseline. They also found that non-OSA patients had a significant increase in the central apnea index the first postoperative night that correlated with the first 24 h opioid requirement.<sup>11</sup> Although the apnea-hypopnea index peaked on postoperative night 3 for both OSA and non-OSA patients, the authors noted that

**Table 6.** Examples of Respiratory Depression Claims Assessed as Definitely/Probably Preventable with Better Monitoring

- Case 1:** An elderly male who had an epidural infusion for a total hip arthroplasty with a fentanyl/bupivacaine mixture delivering ~36 mcg/hr fentanyl was found several hours postoperatively unconscious, apneic and with pinpoint pupils. He aspirated and was intubated and ventilated for 4 days, eventually making a full recovery.
- Case 2:** A middle-aged woman received 74 mg of morphine IV in the first 10 h postoperatively by PCA with a basal infusion of 4 mg morphine/h. Several hours later, she was found by her nurse to be lethargic with coarse respirations at 4–6 per min. The patient had bag mask ventilation and 4 ampules of naloxone IV administered with a rapid return of consciousness. The patient claimed long-term nightmares and memory loss.
- Case 3:** An elderly male with hypertension, diabetes, a thick neck, and a Mallampati class III airway had a postoperative epidural infusion with bupivacaine and morphine after a suprapubic prostatectomy. Twelve hours after the epidural infusion was started (~8.4 mg morphine *via* the epidural space), the patient was noted to be snoring heavily. Shortly afterward, he was found apneic and cyanotic. He was intubated and resuscitated and was noted to have aspirated. He suffered severe anoxic brain damage, required a trach and extensive home care, and died a few years later.
- Case 4:** A middle-aged female underwent a colon resection with a combined general/regional anesthetic. Postoperatively, the epidural mixture of bupivacaine and fentanyl was increased for a complaint of pain and the patient was given promethazine for nausea. The anesthesiologist saw the patient later in the day and found her unarousable. He ordered the rate to be turned down but did not stop it or administer naloxone. The patient coded 30 min later and died a few weeks later.
- Case 5:** A woman in her mid-60s had a general anesthetic for a total abdominal hysterectomy and had morphine PCA postoperatively. In the operating room and recovery room, the patient received 250 mcg of fentanyl IV, 25 mg morphine IV, 50 mg meperidine intramuscularly, and 25 mg hydroxyzine pamoate intramuscularly. On arrival to the floor, the patient was sleepy but arousable. She used the PCA 2 mg morphine bolus twice. Seventy-five minutes after the second PCA bolus, the patient appeared obtunded, and a code blue was called by her physician-daughter in the room. Naloxone was administered promptly, and her oxygen saturation increased from 78% to 95%. The patient complained of cognitive and memory deficits.

PCA = patient-controlled analgesia.

the apnea-hypopnea index values on the first postoperative night may have been artificially lowered by the high utilization of oxygen therapy at that time.

Standard postoperative nursing assessments on most hospital floors occur on arrival, but then vary between every 15 min for 1 h to once every 4 to 6 h.<sup>12</sup> Our data importantly show that at least 42% of patients had been checked by the nurse within 2 h of the RD event. Additionally, in nearly two thirds of the RD claims somnolence was present but not addressed before the RD event. These findings suggest a need for repeated careful assessments postoperatively with increased education regarding signs of opioid toxicity including the correlation between ventilatory depression and excessive sedation. This finding is congruent with a recent study where only 20% of nurses surveyed identified sedation level as the most important predictor of RD, while half

believed respiratory rate was the most important.<sup>13</sup> Notably, less than half (42%) of 135 American Society for Pain Management Nursing members surveyed in a separate study reported that increased assessment of sedation levels helped them intervene earlier and prevent RD.<sup>14</sup> Given that postoperative ventilatory patterns with prolonged apneic episodes clearly correlate with sedation levels,<sup>15</sup> these findings show that improved education regarding monitoring and recognition of early signs of opioid toxicity are warranted.

Our data demonstrate that life-threatening RD can evolve very rapidly, with RD discovered within 15 min of a nursing check in 12 cases. On the basis of these findings, preventive strategies may require continuous monitoring, rather than intermittent checks, and a focus on effective response capacity, as well as event detection. Some organizations have promoted the use of continuous electronic monitoring on all postoperative patients to prevent critical RD events instead of using it only for high-risk patients. The ideal monitor for detecting RD and preventing critical events is controversial, but reviewers in our study judged 97% of these claims as being possibly or probably preventable with better monitoring.

Our finding that basic pulse oximetry monitoring was in use at the time of the RD event in at least one third of claims suggests that respiratory monitoring without centralized or telemetric alarms is insufficient to prevent an RD event. The study by Taenzer *et al.*<sup>16</sup> and Taenzer and Blike<sup>17</sup> demonstrated that continuous pulse oximetry with centralized alarms could be successfully implemented on an orthopedic ward with a reduction in transfers to intensive care units and with a significantly positive return on investment from equipment purchase and staffing costs. Furthermore, nursing staff have been shown to be very responsive to postoperative pulse oximeter alarms when present in conjunction with a notification system to ensure early response to events such as oxygen desaturation or arrhythmias.<sup>18</sup> The use of postoperative end-tidal carbon dioxide monitoring to detect RD has also been suggested, but its lack of familiarity by nursing staff on the floors and poor patient compliance have made its adoption less common. Unfortunately, barriers to implementation of continuous electronic monitoring are significant and include patient compliance, patient sleep disruption, central alarm systems, alarm fatigue by staff, staff familiarity and adoption of monitoring technology, and capital investment requirements. However, these and other data support a more comprehensive monitoring and response approach to prevent what are considered to be avoidable devastating events.

Our data also demonstrated that at least one third of the claims had more than one prescribing physician and that one third had concomitant administration of nonopioid sedating medications. These findings underscore the previously articulated need for institutional policies that support the safe use of postoperative opioid administration.<sup>19,20</sup> Our findings suggest that institutional policies that discourage, limit, or prevent more than one opioid-prescribing physician and the use of

nonopioid sedating medications in patients who are receiving opioids should be encouraged. Of note, this study did not find that a particular opioid or route of postoperative opioid medication was strongly associated with RD, emphasizing the fact that all opioids carry risk. Although 43% of patients had a continuous infusion of opioid (63% neuraxial), this practice is commonly accepted, and without denominator data, it is unclear whether or not the continuous infusions are a significant risk factor for RD. Clinicians should consider removing or decreasing the continuous opioid infusion from local anesthetic infusions or, when coupled with a PCA, in patients who are at high risk for RD or who become excessively sedated.

The explanation for the relatively high percentage of claims associated with lower extremity procedures (41%) is unclear in this data set of closed malpractice claims as it does not contain complete numerator or denominator data. Interestingly, 62% of these lower extremity claims occurred in the 1990s and only 38% occurred in the 2000s. This decline in the number of lower extremity claims associated with RD may be related to the increasing use of opioid-sparing peripheral nerve catheters during this same time period.<sup>21</sup> Consistent with this speculative theory is the lack of any RD claims associated with lower extremity peripheral nerve catheters.

A significant limitation of this study was our dependence on data from the narrative that was not prospectively designed to collect all relevant information related to RD events in a standardized manner. Without this uniform collection of all data, underreporting of contributing factors (such as the use of supplemental oxygen or risk factors for OSA) is likely to have occurred. The low  $\kappa$  value for interrater agreement regarding preventability of the injury reflects the low prevalence of occasions when better monitoring would not have possibly or probably prevented the injury ( $n = 3$ ) in the 92 RD claims.<sup>22</sup> Other limitations of closed claims have previously been described, including retrospective, nonrandom collection of data contributed partially by direct participants instead of impartial observers.<sup>3,4,6</sup> There is no denominator data and incomplete numerator data, making estimates of risk impossible. It is likely that claims are biased toward poorer outcomes and that poorer outcomes bias reviewers toward harsher assessment of the standards of care.<sup>23</sup> Many patients who sustain negligent adverse outcomes do not file malpractice claims.<sup>24</sup> Given these liability factors, the actual occurrence of RD with rescue or poor outcome may be higher than suggested by the small sample analyzed in this report. Despite these limitations, the Closed Claims database provides detailed information on rare adverse events that are otherwise difficult to study in a prospective fashion and can guide hypotheses construction and testing.

### Summary

In summary, data from this study demonstrate that the vast majority of RD events resulting in malpractice claims are preventable, occur primarily within the first 24 h after surgery, and are often preceded by a period of somnolence before significant critical events resulting in death or severe brain damage.

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