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Preventing Extubation Failure by Monitoring Minute Ventilation with the ExSpiron 1Xi™

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Abstract

In the continuing care of postoperative patients who have been extubated, being able to monitor tidal volume and minute ventilation can provide objective criteria to identify respiratory depression and allow for earlier intervention. We present a morbidly obese female patient that was not extubated at the end of the case due to a low tidal volume detected by the anesthesia machine and a real-time non-invasive ventilation monitor that was being trialed for the procedure. This non-invasive ventilation monitor was subsequently useful in continuing to provide continuous information on the patient's respiratory status to provide objective criteria for extubation and after a trial of extubation. Because of its ability to provide values for minute ventilation and tidal volume, rather than subjective criteria such as chest wall rise, this device may prove useful in the context of extubation trials and beyond.

Keywords: Anesthesia; Reversal; Neostigmine; Minute ventilation; Tidal volume; Exspiron; Real-time monitor

Objectives

In current practice, oxygen saturation has been used as the standard for assessing adequate ventilation in postoperative patients [1]. However, in the setting of decreased ventilation, oxygen diffusion still takes place within the functional residual capacity of the lung, thereby consuming the oxygen present [2]. As there is no replacement of the oxygen due to the decreased minute ventilation, a patient's oxygen saturation will decrease rapidly and with little warning. There is latency in pulse oximetry that coincides with the plateau in the sigmoid oxygen dissociation curve [3]. During this time frame, diminished minute ventilation can be detected before the pulse oximetry begins to plummet. In patients with opioid or propofol induced respiratory depression, inadequate reversal of muscle relaxation, or emergence from anesthesia, monitoring of minute ventilation in real time, can be accomplished with the ExSpiron 1Xi. This monitoring device may prove to be a critical patient safety device, by allowing more timely notification of the underlying physiology, thereby allowing for earlier intervention than current pulse oximetry [4]. In postoperative patients, deciding when to extubate can be greatly facilitated by going beyond the information provided by oxygen saturation. While patients are often times extubated in the operating room, others receive a trial extubation or require extended ventilation in the post-anesthesia care unit (PACU). It has been demonstrated that in patients with traumatic brain injury, outcomes are negatively impacted by extubation failures, highlighting the importance of having a means of monitoring ventilation parameters during a trial extubation [5]. Weissman, et al. found that "hypoxemic episodes are common in the PACU…(and) timely resolution of desaturation events outside of the operating room is challenging and protracted, potentially placing patients at increased risk" [6] (Figure 1).

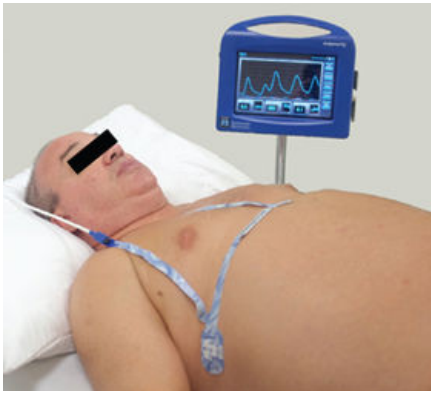

Figure 1: Monitoring tidal volume.

Methods

We present a morbidly obese 49 year old female patient with obstructive sleep apnea who was postoperatively reaccumulating insufflated CO_2 and had a low tidal volume, detected by real-time noninvasive monitoring. This occurred despite the use of an opioid sparing multimodal pain regimen, appropriate reversal of muscle relaxation, and early reduction and shut off of volatile anesthetic gases. The multimodal pain regimen involved the intravenous administration of 1 g acetaminophen at the start of the case and 30 mg ketorolac once the surgeon began closing. Minimal opioids were used during the case, with a total of 100 mcg fentanyl upon induction and bolus of 50 mcg during the two and half hour procedure. The last dose of intermediate acting muscle relaxant, rocuronium, was administered one hour prior to close. A 4/4 TOF with sustained tetanus was observed prior to a dose of 70 mcg/kg neostigmine administration. Despite these measures, signs of respiratory depression were still

present as measured by a low tidal volume. The borderline low minute ventilation and tidal volume detected by the ExSpiron device at the end of the case, correlated within 6-10 cc of the anesthesia machine, thus confirming the accuracy of the device. This allowed the anesthesia care team to make the decision to transport the patient to the PACU intubated, where she was later extubated having met all criteria, but now with the benefit of real time objective evidence of the adequacy of her post-extubation minute ventilation and tidal volumes. No naloxone was administered to the patient in the OR nor PACU as the total fentanyl administered was less than 1.1 mcg/kg. This highly accurate device enabled the anesthesiologists and nurses to use the objective criteria of minute ventilation throughout the post-extubation period, irrespective of the presence of anesthetics, sedatives, or secured airway, reducing the likelihood of an adverse event.

Results

The patient was safely extubated in the PACU with evidence of her ability to maintain an adequate minute ventilation and tidal volume. She was evaluated postoperatively after being extubated and found to be breathing comfortably with a respiratory rate of 18, tidal volume between 350-400, and an oxygen saturation of 100. She was alert and her minute ventilation had returned to normal, allowing her to be safely discharged from the PACU without an increased length of stay.

Discussion

Measuring a decrease in tidal volume and minute ventilation were factors crucial to delaying the extubation of this patient, which prevented her from becoming hypoxemic in the PACU. Additionally, had she received a trial of extubation, detection of this hypoxemia would likely have taken longer to have been detected by pulse oximetry than by the ExSpiron device as the patient had been extubated on 100% FiO_2 [7]. When the functional residual capacity (FRC) has been filled with 100% FiO_2, this masks the inadequacy of ventilation until the patient is on the steep portion of the oxygen dissociation curve. This latency of detection in pulse oximetry would likely have led to an emergent reintubation, which is an undesirable adverse event and outcome. Compounding the problem, a patient on supplemental oxygen will have a higher oxygen saturation that will not indicate the problem of low minute ventilation [8]. As put forward by Williams et al. [9] real time ventilation monitoring has previously proved useful for determining the necessity of respiratory interventions surrounding the extubation of a patient with a mass in the upper airway. Supporting this view, the Joint Commission has suggested that the monitoring of ventilation is a key safety measure in patients receiving opioid analgesia [10]. It is important to note the combination of obesity and obstructive sleep apnea in this patient are both risk factors for postoperative complications. In addition to reaching a decision regarding an appropriate time to safely extubate a patient, monitoring minute ventilation also assists in evaluating patients with sleep apnea for apnea/hypopnea frequency postoperatively [11]. Minute ventilation as measured by non-invasive real-time monitors like the ExSpiron can detect "post-operative apneic events resulting from partial or complete airway collapse due to the residual effects of narcotic administration and volatile and/or intravenous anesthetics" [11].

Conclusion

With the advent of highly accurate tidal volume and minute ventilation monitoring, it appears we are on the cusp of a significant leap in patient safety (Figure 2).

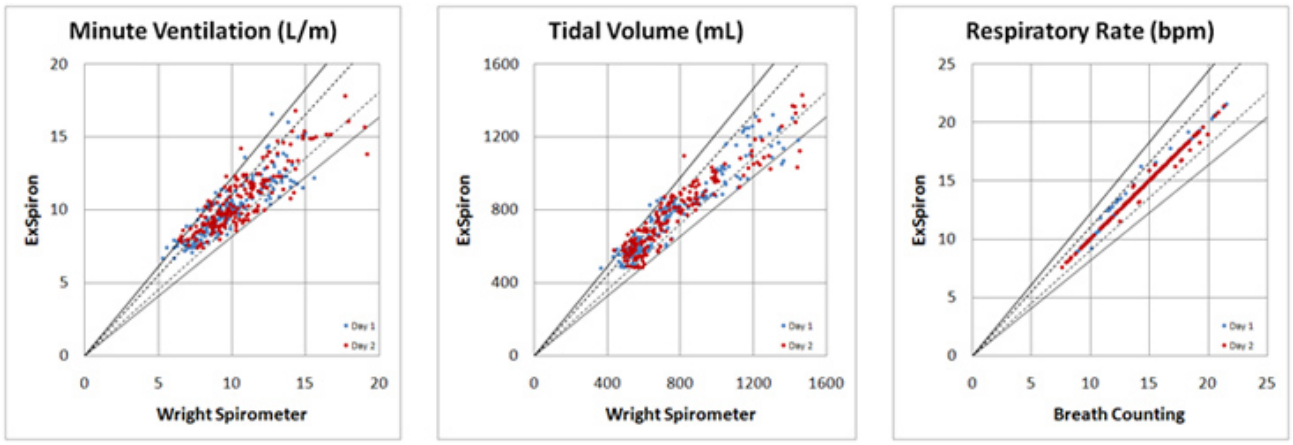

Figure 2: ExSpiron matches spirometry values MV, TV, RR.

We will now be able to utilize these two objective criteria in unintubated patients to assess the adequacy of ventilation in intermediate and high-risk patients and to allow us to preemptively intervene prior to a respiratory crisis or adverse event occurring. This is especially important as the device appears sufficiently sensitive to detect respiratory depression in the setting of opioid-induced, propofol-induced and respiratory muscle weakness [12]. This high degree of sensitivity will likely drive the technology to become pervasive in the post-anesthesia care unit, intensive care units and floors, where patients may be on patient controlled analgesia devices (PCAs). The latter potentially has the greatest safety impact, as a significant number of respiratory depression events occur in patients on PCAs [13]. According to Overdyk, respiratory failure after surgery is the "third most common cause patient safety-related adverse events affecting the Medicare population in U.S. hospitals, accounting for 113 events per 1,000 at-risk patient admissions, and (results) in death or anoxic brain injury in the majority of cases" [14]. As respiratory

depression is a prelude to respiratory failure, early detection of this condition is crucial to improving patient safety.

References

1. Addison PS, Watson JN, Mestek ML, Ochs JP, Uribe AA, et al. (2015) Pulse oximetry-derived respiratory rate in general care floor patients. J Clin Monit Comput 29: 113-120.
2. Karcz M, Papadakos PJ (2013) Respiratory complications in the postanesthesia care unit: A review of pathophysiological mechanisms. Can J Respir Ther 49: 21-29.
3. Hutton P, Clutton-Brock T (1993) The benefits and pitfalls of pulse oximetry. BMJ 307: 457-458.
4. Voscopoulos C, MacNabb CM, Brayanov J, Qin L, Freeman J, et al. (2015) The evaluation of a non-invasive respiratory volume monitor in surgical patients undergoing elective surgery with general anesthesia. J Clin Monit Comput 29: 223-30.
5. Reis HF, Almeida ML, Silva MF, Rocha Mde S (2013) Extubation failure influences clinical and functional outcomes in patients with traumatic brain injury. J Bras Pneumol 39: 330-338.
6. Weissman C, Freeman J (2014) Operational realities in the postanesthesia care unit: staffing and monitoring for safe postoperative care. Anesth Analg 119: 1249-1250.
7. Voscopoulos C, Brayanov J, Ladd D, Lalli M, Panasyuk A, et al. (2013) Evaluation of a Novel Non-invasive Respiration Monitor Providing Continuous Measurement of Minute Ventilation in Ambulatory Subjects in a Variety of Clinical Scenarios. 117: 91-100.
8. Jarzyna D1, Jungquist CR, Pasero C, Willens JS, Nisbet A, et al. (2011) American Society for Pain Management Nursing guidelines on monitoring for opioid-induced sedation and respiratory depression. Pain Manag Nurs 12: 118-145.
9. Williams GW, Sharma A, Chen PR (2014) The Application of a Novel Non-Invasive Respiratory Monitor (ExSpiron™) in the Extubation of a Patient with Persistent Upper Airway Swelling. J Med Cases 5: 388-391.
10. Paice JA, Gordon DB, Contreras J (2012) Joint Commission. The Joint Commission Sentinel Event Alert. The Joint Commission 49(8):1-5.
11. Voscopoulos C, Ladd D, Campana L, George E (2014) Non-invasive respiratory volume monitoring to detect apnea in post-operative patients: case series. J Clin Med Res 6: 209-214.
12. Fleming E, Voscopoulos C, George E (2015) Non-invasive respiratory volume monitoring identifies opioid induced respiratory depression in an orthopedic surgery patient with diagnosed obstructive sleep apnea: a case report. J Med Case Rep 9: 94.
13. Hagle ME, Lehr VT, Brubakken K, Shippee A (2004) Respiratory depression in adult patients with intravenous patient-controlled analgesia. Orthop Nurs 23: 18-27.
14. Overdyk FJ (2010) Postoperative opioids remain a serious patient safety threat. Anesthesiology 113: 259-260.