

Continuous Respiratory Status Visualization Technique: Leveraging High-Fidelity Continuous Respiratory Volume Monitoring for Rapid Patient Assessment

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Introduction: Respiratory monitoring and assessment is crucial for improved patient outcomes in most hospital settings. Higher acuity settings like ICUs employ more staff, additional monitoring equipment, and sophisticated data collection and processing systems capable of gathering, aligning, and processing numerous data streams. Data interpretation is often more challenging than collection, as nearly all interpretations are performed by highly-trained clinicians who often need to review substantial amounts of data to make correct clinical decisions. Such an approach is not sustainable in the majority of lower-acuity settings, like the post anesthesia care unit (PACU) or the general hospital floor (GHF), where patient monitoring and decision making is often based on “spot-checks” and sparse data, rather than continuous data trends. This problem is further complicated by the current monitoring standards which are either subjective (e.g. visual assessment by an RN) or based on secondary measures of respiratory status (e.g. SpO₂ or EtCO₂). Here we demonstrate a novel visualization technique, based on continuous respiratory volume monitoring (RVM) data, which allows clinicians to assess patient respiratory status quickly and efficiently. By reducing the variability of the high-fidelity RVM data while preserving key temporal and dimensional features, we were able to synthesize hours of patient data into simple and easy-to-interpret plots, allowing clinicians to make clinical decisions faster, with improved patient safety, reduced staff workload, and healthcare cost-savings.

Methods: Continuous RVM data (ExSpirom, Respiratory Motion, Inc.), O₂ supplementation status, SpO₂ alarm records and PCA opioid administration data were collected from 12 patients (5 females; mean age: 69yrs, range: 58-84; mean BMI: 31.2 kg/m² range:22.0-49.1kg/m²) during their stay in the PACU following orthopedic surgery. Note that these patients were part of a much larger observational IRB-approved study, but for the purposes of this demonstration, we present only a small subset of the enrolled patients. Here, a low MV event (LMVe) was defined as $MV < 40\% MV_{PRED}$ (based on the patient’s BSA) sustained for at least 60 seconds. Low SpO₂ alarm limit was set at <90% and sporadic low SpO₂ readings (<2 min) were considered “false alarms.”

Results: Each patient is visualized along an individual axis, parallel to the Y-axis (see Fig 1). The dashed blue line represents each patient’s timeline in the PACU, with arrival at the PACU aligned with the X-axis. Supplemental O₂ is displayed as a solid red line overlaid on top of the dashed blue, spanning the regions where supplemental O₂ was delivered. Along each patient axis we display LMVe with red ellipses. The length of each ellipse (along the y-axis) denotes the temporal duration of an LMVe or a cluster of LMVe (if in close succession), whereas the width of each ellipse corresponds to the severity of each event with wider ellipses corresponding to more severe (i.e. lower MV) LMVe. In addition, PCA opioid doses are visualized as green asterisks, apneic pauses longer than 30-sec as black dots, and Low SpO₂

alarms as purple diamonds. "False SpO₂ alarms" are displayed with hollow symbols and SpO₂ alarms lasting > 2min are displayed with solid symbols.

Conclusions: As more clinical decisions are driven by quantitative data, new ways of synthesizing and visualizing data can assist with interpretation and quicker patient assessment. This is particularly important when working with high-fidelity respiratory volume data in non-intubated patients. The naturally occurring variability in these data can make it challenging for a clinician to combine trends and correlative or causal effects from the raw metrics alone, which is why we propose that a synthesized visualization may be able to assist not only with clinical decision making, but may also reduce workload and associated healthcare costs.

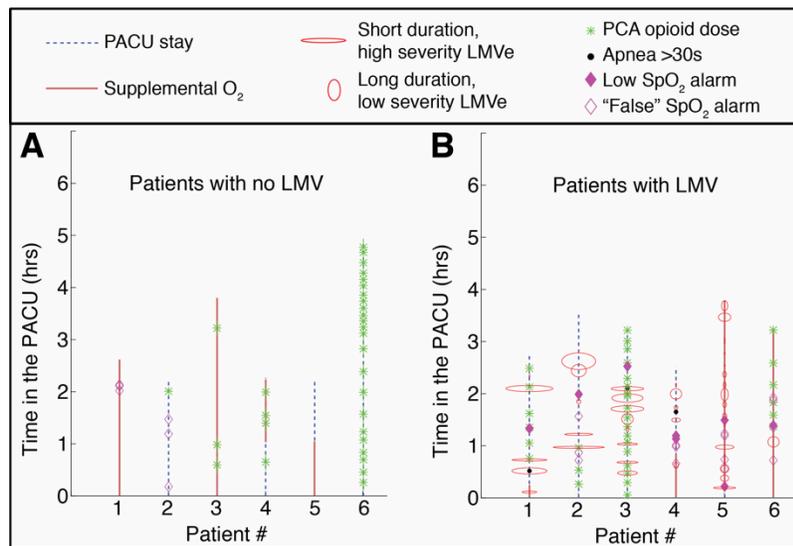


Figure 1: Visualization of patient respiratory status in the PACU. PACU stay is displayed as a dashed blue line, with arrival at the PACU aligned with the X-axis. Supplemental O₂ is displayed solid red on top of the dashed blue. An LMVe is represented by a red ellipse. This visualization allows for easy differentiation between LMVe with less than 10% difference (i.e. 40% MVpred vs 30% MVpred) and with temporal spacing of less than 10 minutes on an axis that spans a full 8-hour shift. Green asterisks represent PCA opioid doses, apneic pauses are displayed as black dots, and Low SpO₂ alarms as purple diamonds (solid for alarms >2min, hollow for "False SpO₂ Alarms" <2min).