Rating the Severity of Opioid-Induced Ataxic Breathing in Healthy Humans

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Abstract: Opioid induced respiratory depression is traditionally recognized by assessment of respiratory rate, arterial oxygen saturation, end-tidal CO_2, and mental status. Although an irregular or ataxic breathing pattern is widely recognized as a manifestation of opioid effects, the presence of ataxic breathing is not routinely monitored. A major obstacle to widespread monitoring for ataxic breathing is the lack of a reproducible metric for it and the necessity for manual offline analysis. We explored the feasibility of using an automated machine learning algorithm to quantify the severity in ataxic breathing pattern for healthy volunteers experiencing opioid induced respiratory depression. The primary aim was to assess the agreement among all raters, including the machine learning algorithm and the domain experts. The secondary aim was to compare the scores from the machine learning algorithm to those from the domain experts.

After IRB approval, informed written consent was obtained from 26 volunteers (13 male, 13 female) who were given target controlled infusions of propofol and remifentanil with the goal of modeling light sleep together with opioid induced ventilatory depression. Respiration data were collected from chest and abdomen Respiratory Inductance Plethysmography (RIP) bands and a nasal pressure transducer sampled from a nasal cannula during steady state periods. Three domain experts scored the severity of ataxic breathing in accordance with predefined scoring guidelines. Krippendorff's alpha and Vanbelle's Kappa were used to assess the level of agreement in ataxic breathing severity scores from the machine learning algorithm and the domain experts.

Krippendorff's alpha was 0.912 (CI 0.852- 0.949) for the RIP-based algorithm and 0.899 (CI 0.819- 0.941) for the intranasal pressure-based algorithm. Vanbelle's Kappa was 0.976 (0.951-0.983) for RIP and 0.893 (0.813-0.936) for intranasal pressure.

We concluded it may be feasible for a machine learning algorithm to quantify ataxic breathing severity in a manner consistent with a panel of domain experts. This measure may be helpful in conjunction with measures of respiratory rate and SpO_2 to identify patients at risk for opioid induced respiratory depression.