插管和自主呼吸患者进行手术镇静时，MV 和 $EtCO_2$ 的关系

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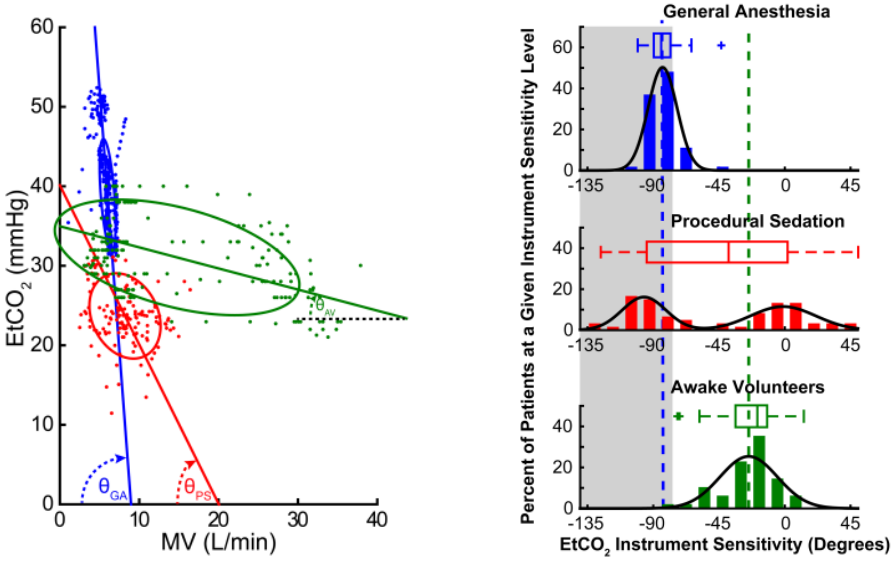
背景：反映动脉 $PaCO_2$ 的呼气末二氧化碳（$EtCO_2$）可在全麻下监测插管患者的呼吸状态，而对于非插管和自主呼吸患者，被证实通常是不准确和不充分的。进行程序化镇静手术（如内窥镜检查，结肠镜检查）患者的呼吸状态监测非常重要。这些手术可以在手术室进行，但也经常由非麻醉医生在手术室外完成。在该研究中，评估了常规 $EtCO_2$ 监测反映非插管手术患者麻醉下通气变化的能力，并将这些发现与全麻插管患者以及自主呼吸的志愿者得到数据进行比较分析。

方案：呼吸量监测系统（RVM）可以持续收集每分钟通气量（MV），潮气量（TV）和呼吸频率（RR）。本研究使用 RVM 和二氧化碳图同时采集分别来自三个患者组的 160 名患者数据：脊麻和程序化镇静的非插管手术患者（n=58），全麻插管患者（n=54），清醒的自主呼吸志愿者（n=48）。$EtCO_2$ 仪器灵敏度定义为每位患者 $EtCO_2$ 和 MV 测量值 Deming 回归的斜率，并表示为与 x 轴的角度（θ）。

结果：大多数患者 $EtCO_2$ 和 MV 测量结果呈负相关，但在三个分组中存在严重系统性差异。全麻患者中，较小的 MV 变化导致 $EtCO_2$ 较大变化（高灵敏度，θ=-83.6±9.9˚）。相反，在清醒的志愿者中，较大的 MV 变化对应 $EtCO_2$ 变化不明显（低敏感度，θ=-24.7±19.7˚, $p<0.0001$vs 全麻）。在程序化镇静患者中，$EtCO_2$ 敏感性呈双峰分布，$EtCO_2$ 高敏感性患者类似于全身麻醉患者，而 $EtCO_2$ 敏感性低的患者类似于清醒志愿者。

结论：对于进行程序化镇静的非插管患者来说，$EtCO_2$ 不能提供足够的通气变化灵敏度，相比于对全麻患者的监测，灵敏度大大降低。这表明采用 $EtCO_2$ 作为非插管患者的呼吸状态变化的监测方案是不太理想的。相对的，使用呼吸量监测系统（RVM）直接监测每分钟通气量（MV）可能更适合评估非插管患者的通气是否充足。



The relationship between Minute Ventilation and End Tidal CO_2 in Intubated and Spontaneously Breathing Patients undergoing Procedural Sedation

Background: Monitoring respiratory status using end tidal CO_2 ($EtCO_2$), which reliably reflects arterial $PaCO_2$ in intubated patients under general anesthesia, has often proven both inaccurate and inadequate when monitoring non-intubated and spontaneously breathing patients. This is particularly important in patients undergoing procedural sedation (e.g., endoscopy, colonoscopy). This can be undertaken in the operating theater, but is also often delivered outside the operating room by non-anesthesia providers. In this study we evaluated the ability for conventional $EtCO_2$ monitoring to reflect changes in ventilation in non-intubated surgical patients undergoing monitored anesthesia care and compared and contrasted these findings to both intubated patients under general anesthesia and spontaneously breathing volunteers.

Methods: Minute Ventilation(MV), tidal volume(TV), and respiratory rate(RR) were continuously collected from an impedance-based Respiratory Volume Monitor(RVM) simultaneously with capnography data in 160 patients from three patient groups: non-intubated surgical patients managed using spinal anesthesia and Procedural Sedation(n=58); intubated surgical patients under General Anesthesia(n=54); and spontaneously breathing Awake Volunteers(n=48). $EtCO_2$ instrument sensitivity was calculated for each patient as the slope of a Deming regression between corresponding measurements of $EtCO_2$ and MV and expressed as angle from the x-axis(θ). All data are presented as mean ± SD unless otherwise indicated.

Results: While, as expected, $EtCO_2$ and MV measurements were negatively correlated in most patients, we found gross systematic differences across the three cohorts. In the General Anesthesia patients, small changes in MV resulted in large changes in $EtCO_2$(high sensitivity, θ=-83.6±9.9˚). In contrast, in the Awake Volunteers patients, large changes in MV resulted in insignificant changes in $EtCO_2$(low sensitivity, θ=-24.7±19.7˚, $p<0.0001$ vs General Anesthesia). In the Procedural Sedation patients, $EtCO_2$ sensitivity showed a bimodal distribution, with an approximately even split between patients showing high $EtCO_2$ instrument sensitivity, similar to those under General Anesthesia, and patients with low $EtCO_2$ instrument sensitivity, similar to the Awake Volunteers.

Conclusions: When monitoring non-intubated patients undergoing procedural sedation, $EtCO_2$ often provides inadequate instrument sensitivity when detecting changes in ventilation. This suggests that augmenting standard patient care with $EtCO_2$ monitoring is a less than optimal solution for detecting changes in respiratory status in non-intubated patients. Instead, adding direct monitoring of MV with an RVM may be preferable for continuous assessment of adequacy of ventilation in non-intubated patients.