**ROUGH DRAFT**

*Rough drafts can be very rough and should be very fast - just try to get the ideas out on to paper.  Ideally, letting the draft flow as best as possible, taking a break, then revisiting with editing. Short sentences. Punch intro sentences to paragraphs, end paragraphs that collect the important points then transition to the next. One idea per paragraph.*

*Good overall how-to*[*https://x.com/nicholaszaorsky/status/1479549305623035904?s=11*](https://x.com/nicholaszaorsky/status/1479549305623035904?s=11)

**Title:**

Comparing Venous Blood Gas and Arterial Blood Gas in Hypercapnic Respiratory Failure

**Introduction:**

*“Problem, Gap, Hook” Heuristic:*[*https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4602011/pdf/40037\_2015\_Article\_211.pdf*](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4602011/pdf/40037_2015_Article_211.pdf)

Arterial blood gases (ABGs) are considered the gold standard for assessing acid-base balance, oxygenation and ventilation status, and remain essential in the management of hypercapnic respiratory failure. However, obtaining an ABG can be uncomfortable for patients, time-consuming and technically challenging, often requiring multiple attempts. Potential complications include arterial injury, thrombosis, air or clotted blood embolism, arterial occlusion, hematoma, and aneurysm formation.

Hypercapnia results from lungs’ inability to adequately remove carbon dioxide from the bloodstream, leading to its accumulation. On ABG, hypercapnia is defined as greater than 45 mmHg while on VBG, hypercapnia is greater than 50 mmHg. VBGs are increasingly used in emergency settings as a screening tool for hypercapnia due to ease of collection and reduced risk, though they are less precise in measuring pCO2 compared with ABGs.

Despite their growing use, there has been limited studies comparing VBG versus ABG in diagnosis of hypercapnic respiratory failure. In a study by Davies et. al, hospitalized patients with known or suspected hypercapnic respiratory failure underwent near-simultaneous ABG and VBG testing. Results demonstrated close agreement in PaCO2 values between ABG and calculated values derived from VBGs, supporting the use of VBGs in monitoring hypercapnic patients. Similarly, a review by Lacy et. al analyzed a prospective study which found VBG to have 100% sensitivity in identifying hypercapnia in those with respiratory failure due to COPD exacerbation, pneumonia, heart failure and asthma using Pv CO2 greater than 45 mmHg. Ak et. al published an additional prospective study in COPD patients in acute exacerbation that found VBG to identify hypercapnia in 100%. In contrast, McKeever found wide variability between arterial and venous CO₂ levels in COPD patients with acute exacerbations, underscoring the limitations of VBG precision.

The objective of this study was to determine whether VBG measurements can reliably identify hypercapnia compared with ABGs. The outcomes evaluated include endotracheal intubation, initiation of non-invasive ventilation (NIV), 60-day mortality and diagnosis for hypercapnia among three groups: patients with hypercapnia on ABG, on VBG, or based on calculated.

**Methods:**

<https://www.equator-network.org/reporting-guidelines/record/>

1. *How did we get the dataset:  Requested all data from 2022 from TriNetX research network that had at least 1 criteria that would indicate hypercapnia may be present*
2. *What data cleaning did we do: ensured institution was submitting all data.*
3. *A “Table 1” to describe the variables in the dataset*

<https://theeffectbook.net/ch-DescribingVariables.html>

*Guide to help make figures of Table 1 (to show distribution)*

<https://jthomasmock.github.io/gtExtras/articles/plotting-with-gtExtras.html>

1. *Description of correlations with the outcomes of interest*

<https://theeffectbook.net/ch-DescribingRelationships.html>*(the rest of the book looks pretty good, too)*

This retrospective cohort study using de-identified patent data from the 2022 TriNetX research network, which aggregates EMR data from participating health systems. The University of Utah Institutional Review Board reviewed the study protocol and determined the project met criteria for exemption (IRB #00184622).

**Study Population**

Patients were eligible for inclusion if they had at least one documented arterial blood gas (ABG) or venous blood gas (VBG) measurement during an acute care encounter. For patients with VBGs, a “calculated ABG” partial pressure of carbon dioxide (pCO₂) was also estimated using the Farkas equation: Estimated arterial pCO₂=VBG pCO₂−0.22×(93%−VBG O₂ saturation). Patients with missing key demographic or outcome data were excluded.

**Table 1A and 1B** provides a summary of the dataset. The table divides the data into six groups: patients who had 1) no ABG, 2) hypercapnia on ABG, 3) no hypercapnia on ABG, 4) no VBG, 5) hypercapnia on VBG, 6) no hypercapnia on VBG. It includes the mean and standard deviation for age and BMI, as well as the percentage of sex and the distribution of race, ethnicity and region in the United States. Additionally, the table presents the prevalence of key comorbidities, including obstructive sleep apnea (OSA), asthma, chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), neuromuscular disorders, pulmonary hypertension, chronic kidney disease (CKD) and diabetes. Furthermore, the minimum, maximum, median, mean, and standard deviation of pCO2 levels from both VBGs and ABGs are also reported.

For the regression analyses, the cohorts were categorized into three groups: below normal pCO2 < 35 mmHg, normal pCO2 (35–45 mmHg for ABG/Calculated ABG; 35–50 mmHg for VBG), above normal (>45 mmHg for ABG/Calculated ABG; >50 mmHg for VBG). The outcomes that were evaluated included invasive mechanical ventilation, noninvasive ventilation, 60-day mortality and an assignment of an ICD-19 code for hypercapnic respiratory failure.

**Logistic Regression Models**

Separate logistic regression models were estimated within each cohort to evaluate the association between pCO₂ category (below normal, normal, above normal) and each of the four outcomes listed above. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated, using the normal pCO₂ group as the reference. Odds ratios from categorical models were displayed using forest plots on a logarithmic scale, stratified by cohort.

#### **Propensity Score Weighting**

To reduce confounding, inverse probability of treatment weights (IPTWs) were applied. Propensity scores were estimated for the likelihood of obtaining an arterial or venous blood gas, belonging to each cohort based on demographic variables (age, sex, race, ethnicity, BMI, location), comorbid conditions (COPD, asthma, OSA, CHF, neuromuscular disorders, pulmonary hypertension, CKD, diabetes) and other objective data including vital signs and basic initial labs. Weights were stabilized and trimmed at the 1st and 99th percentiles to minimize the influence of extreme values. Covariate balance was evaluated using standardized mean differences, with <0.1 indicating acceptable balance. Additionally, propensity score distributions were compared graphically to assess overlap between groups before and after weighting.

#### **Restricted Cubic Spline Models**

To capture nonlinear relationships between continuous pCO₂ and outcomes, weighted logistic regression models with restricted cubic splines were fit using the rms package in R. Predicted probabilities of each outcome were estimated across the full observed range of pCO₂ values, with 95% confidence intervals. Spline-based predicted probabilities were visualized as smooth curves with shaded confidence intervals.

**Results:**

* *Results from cleaning and inclusion – Dr. Locke*

*Guidance on table formatting:*[*https://x.com/carlislerainey/status/1799022485733875770?s=46&t=5eJ6uoTQrbbYTlHIOnRYRg*](https://x.com/carlislerainey/status/1799022485733875770?s=46&t=5eJ6uoTQrbbYTlHIOnRYRg)

*Options of how to display data: https://www.data-to-viz.com/*

A total of \*\*\* patients met inclusion criteria for the study. Patients were categorized according to blood gas type and the presence or absence of hypercapnia, resulting in six analytic groups. Baseline demographic and clinical characteristics for these groups are summarized in Table 1A and 1B.

**Table 1A: Description of Variables by ABG Group.**

**Table 1B: Description of Variables by VBG Group.**

Figure 1 displays the adjusted odds ratios with 95% confidence intervals, comparing below-normal and above-normal pCO₂ groups to the normal reference group fort invasive mechanical ventilation, noninvasive ventilation, 60-day mortality, and hypercapnic respiratory failure.

**Figure 1: Inverse Propensity Weighted Odds Ratio of Outcomes by PCO2 Category**

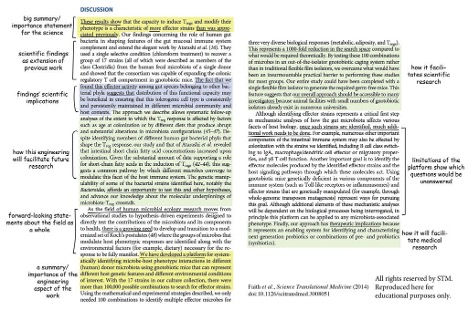
To further examine the continuous relationship between PCO2 and clinical outcomes, restriced cubic spline models were constructed. Figure 2A, 2B and 2C present the predicted probabilities for each outcome across pCO2 values, stratified by ABG, VBG and calculated ABG groups.

**Figure 2A: Inverse Propensity Weighted Predicted Probability by ABG.**

**Figure 2B: Inverse Propensity Weighted Predicted Probability by VBG.**

**Figure 2C: Inverse Propensity Weighted Predicted Probability by Calculated ABG.**

**Discussion:**



* *Restate the high level results*
* *Compare to prior studies*
* *Highlight consistencies and differences*
* *Strengths & Limitations*
* *Clinical implications*

**References:**