Exploring the Relationship between SpO2, PaO2, and PbtO2 in Patients with Severe TBI

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Background & Purpose:

- The relationship between systemic and cerebral oxygenation is critical to understanding the dynamics of oxygen delivery and consumption after brain injury.
- Brain tissue oxygen (PbtO2) reflects flow and dissolved oxygen content; the impact of changes in the oxygen dissociation curve or the fraction of oxygen extracted by injured tissue is incompletely understood.
- The purpose of this study is to observe the interrelation between arterial oxygen (PaO2), peripheral oxygen saturation (SpO2), and PbtO2 in patients after severe traumatic brain injury (sTBI).

Methods:

- We performed a retrospective, observational cohort study of patients undergoing invasive multimodality monitoring for sTBI from April 2015 to December 2021.
- High-frequency physiologic data including continuous bedside plethysmography (SpO2) and PbtO2, was down-sampled to 10-min windows and time-synchronized with arterial blood gas (ABG) measurements arterial saturation of oxygen (SaO2) and PaO2 obtained during monitoring period.
- We compared the occurrence of adequate PbtO2 (>20 mmHg) by different strata of SpO2.

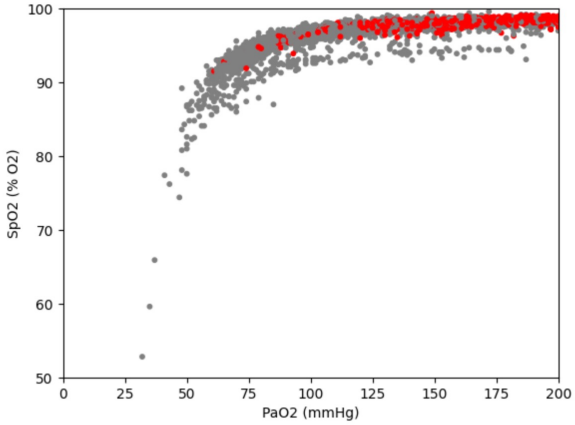

Figure 1: Oxygen-dissociation curve from 175 sTBI patients with PbtO2, SpO2, and multiple arterial blood gas measurements. There was no consistent shift in the oxygen dissociation curve based on P:F ratio (colorgray = P:F<300, color red = P:F≥300.

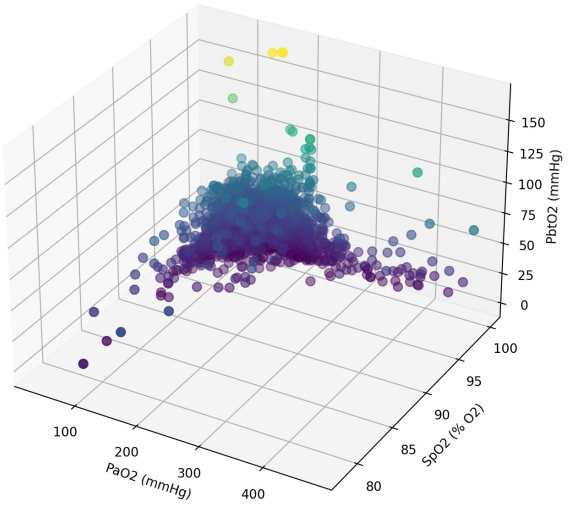

Figure 2: Peripheral and central oxygen-dissociation curves showing an increase in PbtO2 with increasing SpO2 despite optimal oxygen loading onto hemoglobin. Colors are representative of PbtO2 level.

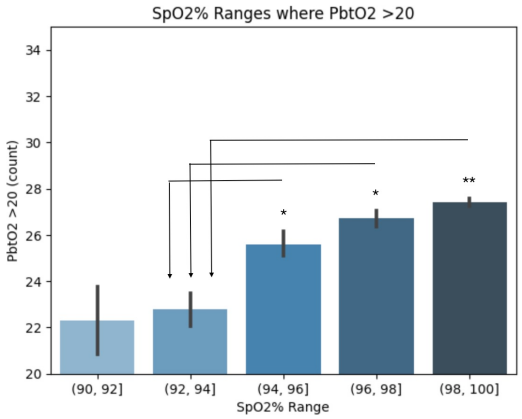

Figure 3: PbtO2 > 20 mmHg were more common when SpO2 values were 98-100% vs 92-94%, t=-4.4, p<0.001; 94-96%, t=-5.1, p<0.01; or 96-98%, t=-2.7, p<0.01.

Table 1: Physiologic Measurements and ABG Data	
FiO2, % (median[IQR])	45 [40-55]
PaO2, mmHg (median[IQR])	129 [95-169]
SpO2, % (median[IQR])	99.9 [98.8-100]
PbtO2, mmHg (median[IQR])	24.7 [14-36.1]
P:F Ratio (median[IQR])	307.5 [206.5-392.1]

Results:

- There were 175 patients (age 42+/-18 years; 82% male) with 110,169 physiologic data points and 51,025 ABG measurements.
- The O2-dissociation curve variably shifted, with optimal loading in the range of SpO2 94-100% and PaO2 > 100 mmHg. Shifts were not consistently stratified between patients with P:F < 300 vs P:F > 300 (Figure 1).
- PbtO2 increased with SpO2 as O2-dissociation curve flattened and was maximized at SpO2 > 98%.and PaO2 150-200 mmHg (Figure 2).
- PbtO2 was more likely to be > 20 mmHg when SpO2 values were 98-100% (Figure 3).

Conclusions:

- SpO2 *higher* than recommend standards may contribute to better brain tissue oxygenation.
- A shift in the O2-dissociation curve across patients with sTBI suggests higher than normal PaO2 is required to optimally load hemoglobin.
- Despite maximal loading, SpO2 may reflect changes in oxygen delivery or consumption impacting brain tissue oxygen at relatively minor decreases in SpO2.

References:

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