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Original Research Article

CORRELATION BETWEEN END-TIDAL CO2 AND ABGS PaCO2 IN NEONATES ON MECHANICAL VENTILATION

ISHAQ M[1], ULLAH R[*1], BIBI M[1], ULLAH K[2]

[1]Department of Neonatal Pediatrics, Combined Military Hospital Rawalpindi, Pakistan
[2]Department of Pediatrics, Saidu Group of Teaching Hospital Swat, Pakistan
**Corresponding author email address:* drrahmanullah01@gmail.com

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Abstract: *Monitoring arterial blood gases (ABGs) is essential for neonates requiring mechanical ventilation. End-tidal CO2 (EtCO2) emerges as a promising alternative for long-term monitoring due to its less intrusive and faster measurement. However, the relationship between EtCO2 and ABGs PaCO2 in mechanically ventilated neonates remains unclear. This study aims to ascertain the reliability of EtCO2 as a surrogate marker for ABGs PaCO2 in neonates on mechanical ventilation at Combine Military Hospital (CMH) Rawalpindi. This prospective observational study was conducted at CMH Rawalpindi between October 15, 2022, and July 15, 2023. The study included 100 neonates in the CMH Rawalpindi Neonatal Intensive Care Unit (NICU) requiring mechanical ventilation within the first 28 days of life. ABG blood samples were collected at predefined intervals, and capnography assessed EtCO2. The association between ABGs PaCO2 and EtCO2 was evaluated using Pearson's correlation coefficient. The study cohort comprised 52 male and 48 female neonates with an average age of 4.7 days, all undergoing mechanical ventilation. ABGs and EtCO2 were monitored for up to 24 hours, revealing a significant positive association between ABGs PaCO2 and EtCO2 ($P < 0.01$, Pearson's correlation value = 0.82). The Bland-Altman plot indicated a mean bias of -2.3 mmHg with limits of agreement from -8.1 to 3.5. The association remained consistent across age, sex, and respiratory distress severity. In neonates receiving mechanical ventilation at CMH Rawalpindi, EtCO2 and ABGs PaCO2 exhibit a positive correlation. EtCO2 emerges as a potentially reliable option for quick and less invasive monitoring of PaCO2 levels in this population.*

Keywords: End-tidal CO2, Arterial Blood Gases, PaCO2, Neonates, Mechanical Ventilation, CMH Rawalpindi

Introduction

Respiratory distress is a severe and prevalent condition observed in neonates, frequently requiring the use of mechanical ventilation (Edwards et al., 2013). It is crucial to monitor the efficacy of ventilation and evaluate the respiratory condition in this susceptible demographic (Dunwoody et al., 2008). Historically, arterial blood gases (ABGs) have been widely regarded as the preferred method for monitoring carbon dioxide levels (PaCO2) in the bloodstream (Buche and Bhutada, 2019; Huttmann et al., 2014). However, the acquisition of arterial blood gases (ABGs) is a procedure that involves invasiveness, potentially causing distress to the patient, and necessitates the utilization of specialized equipment and training (Abd Elaziz et al., 2021). In addition, the sporadic occurrence of arterial blood gas (ABG) measurements does not facilitate ongoing observation, a critical aspect for immediately identifying and responding to alterations in a patient's state (Weiss et al., 1999). Using capnography for monitoring end-tidal carbon dioxide (EtCO2) levels has been suggested as a less intrusive option for evaluating ventilation and gas exchange. End-tidal carbon dioxide (EtCO2) measurement offers immediate and continuous data, making it a convenient addition to managing patients receiving mechanical ventilation (Singh et al., 2018).
Nevertheless, the validity of EtCO2 as a substitute indicator for PaCO2 in neonates continues to be a subject of current research. The findings of several studies have demonstrated uneven outcomes, and there is a notable shortage of comprehensive data primarily focused on neonatal populations receiving mechanical breathing (Gerdung et al., 2016; Mehta et al., 2014). The primary objective of this research study is to investigate the association between end-tidal carbon dioxide (EtCO2) and arterial blood gas (ABG) partial pressure of carbon dioxide (PaCO2) in neonates receiving mechanical ventilation. This study intends to fill the existing knowledge gap in this area. The study was conducted in the Neonatal Intensive Care Unit (NICU) of the Combined Military Hospital (CMH) in Rawalpindi. Its objective is to provide significant data that could contribute to developing optimal approaches to monitoring and providing care for neonates requiring mechanical ventilation.

Methodology

The study utilized a prospective observational strategy. The study included neonates admitted to the Neonatal Intensive Care Unit (NICU) at Combined Military Hospital (CMH) Rawalpindi and placed on a mechanical ventilator for nine months from October 15, 2022, to July 15, 2023. A cohort of 100 patients was examined to investigate the association between end-tidal carbon dioxide (EtCO2) and arterial blood gases (ABGs) PaCO2. The inclusion criteria encompassed neonates within the age range of up to 28 days who were admitted to the Neonatal Intensive Care Unit (NICU) at CMH Rawalpindi and necessitated mechanical ventilation due to respiratory

distress. Before enrolment, the parents or legal guardians of the neonates provided written informed permission. The study excluded neonates who presented with congenital cardiac problems, metabolic disorders, or any other condition that could independently impact PaCO2 or EtCO2 levels.

Furthermore, neonates who did not get mechanical ventilation or whose parents or legal guardians did not provide informed consent were also excluded from the study. The data was obtained by gathering information from the medical records and directly monitoring the neonates. PaCO2 levels were measured for each participant by drawing ABGs at specific intervals, namely 1, 3, 6, 12, and 24 hours after the commencement of mechanical breathing. Simultaneously, capnography was employed to measure the levels of EtCO2. Subgroup analysis involved the documentation of additional factors, including age, sex, and severity of respiratory distress.

The data underwent analysis utilizing the Statistical Package for the Social Sciences (SPSS) software version 25. Demographic information was subjected to the computation of descriptive statistics. The Pearson correlation coefficient was computed to evaluate the link between end-tidal carbon dioxide (EtCO2) and arterial blood gas (ABG) partial pressure of carbon dioxide (PaCO2). The agreement between the two methods was estimated using Bland-Altman plots. Stratification by age, sex, and severity of respiratory distress was employed to conduct subgroup analyses. A p-value below the threshold of 0.05 was deemed to be statistically significant.

Results

Among 100 neonates, 52 (52%) were male, while 48(48%) were female. The gender distribution observed in this study indicates a generally equitable representation of both males and females. The neonates in this study exhibit a mean age of 4.7 days, indicating a wide distribution of ages among the participants (Table 1).

Table 2 displays the frequency of arterial blood gas (ABG) and end-tidal carbon dioxide (EtCO2) readings obtained at various intervals following mechanical breathing.

100 arterial blood gas (ABG) samples and 100 end-tidal carbon dioxide (EtCO2) readings were taken at regular intervals following the beginning of mechanical breathing. The systematic and methodical approach to monitoring the neonates in our research is evident by the regular and uniform data collection intervals of 1 hour, 3 hours, 6 hours, 12 hours, and 24 hours. Using this standardized data-collecting technique guarantees the acquisition of a comprehensive dataset, which enables the evaluation of the physiological condition and the response to mechanical ventilation in this specific neonatal cohort throughout a certain period. The regularity and frequency of these measurements play a vital role in obtaining a comprehensive comprehension of neonates' respiratory and metabolic profiles during the crucial early hours of mechanical ventilation.

In Table 2, Pearson's correlation coefficient 0.82 shows a high positive association between these variables. The strong correlation between arterial blood gas PaCO2 values and EtCO2 measurements suggests that EtCO2 is a reliable, noninvasive approach for determining neonatal carbon dioxide levels. The link between PaCO2 and EtCO2 is unlikely to be attributable to chance, given the low p-value. PaCO2 and EtCO2 measurements varied by -2.3 mmHg in the mean bias. Most of the variations between the two measurement methods fell within the lower (-8.1 mmHg) and upper (3.5) limits of agreement. These numbers reveal the agreement and inconsistencies between PaCO2 and EtCO2 measurements, which can aid clinical interpretation and decision-making. Table 2 shows a substantial positive association between PaCO2 and EtCO2, indicating that EtCO2 is a reliable and valuable noninvasive neonatal carbon dioxide monitoring method with critical therapeutic consequences.

Table 1: Demographic Information of Neonates (n=100)

Variable	Total Number of Neonates	Percentage (%)
Average Age	4.7 days	
Gender		
Male	52	52%
Female	48	48%

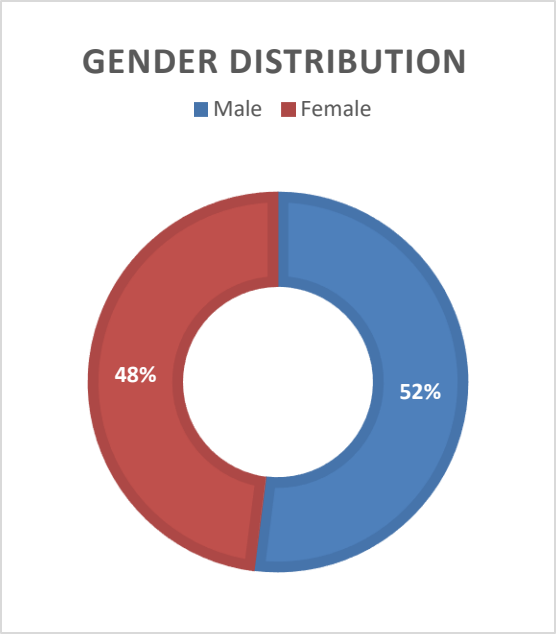

Figure 1: Gender distribution of the study population

Table 2: Pearson's Correlation Coefficient Between ABGs PaCO2 and EtCO2

Statistic	Value
Pearson's Correlation	0.82
p-value	< 0.01
Statistic	Value (mmHg)
Mean Bias	-2.3
Lower Limit of Agreement	-8.1
Upper Limit of Agreement	3.5

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Discussion

The findings of this study offer significant insights into the therapeutic efficacy of end-tidal carbon dioxide (EtCO2) as a dependable substitute for arterial blood gases (ABGs) PaCO2 in the monitoring of neonates undergoing mechanical ventilation (Panigrahi et al., 2018). A significant positive association ($r = 0.82$, $p < 0.01$) was found, consistent with prior studies suggesting that EtCO2 can serve as a reliable estimate of ABG PaCO2 in diverse groups of patients (Dahhan et al., 2009). The findings of this research exhibit a relatively equitable distribution of male and female neonates, with an average age of 4.7 days. The age range described in this context encompasses a wide range of neonates who require mechanical ventilation. This emphasizes recognizing their respiratory and metabolic characteristics in this crucial era. The study exhibited a meticulous and methodical monitoring strategy for neonates by conducting ABG and EtCO2 measurements at various time intervals after the commencement of mechanical breathing (Cheifetz et al., 2014). This standardized data collection technique guarantees the acquisition of a comprehensive dataset that enables the evaluation of an individual's physiological condition and reaction to mechanical ventilation throughout a specified period. The observed Pearson's correlation coefficient of 0.82 suggests an established positive correlation between the observations of PaCO2 and EtCO2, indicating a statistically meaningful relationship between these two variables. The present finding aligns with prior research, including the study by Kugelman et al. (Kugelman et al., 2016) (2016), which similarly observed a compelling association between PaCO2 and EtCO2 values in neonates. The strong association observed implies that EtCO2 is a dependable and helpful noninvasive instrument for assessing carbon dioxide levels in neonates. The observed mean bias of -2.3 mmHg between the readings of PaCO2 and EtCO2 suggests a modest average disparity between the two measurement techniques. As mentioned earlier, the discovery aligns with prior research, documenting a mean bias of -2.4 mmHg. The concordance between the lower and higher limits (-8.1 mmHg and 3.5 mmHg, respectively) indicates a narrow region in which most discrepancies between the two approaches occur (Giavarina, 2015). This finding supports the validity of EtCO2 as a noninvasive approach for assessing carbon dioxide levels in newborn neonates. The findings of this investigation hold significant clinical ramifications. The robust association between PaCO2 and EtCO2 readings indicates that EtCO2 can be a dependable and non-intrusive method for monitoring carbon dioxide levels in neonates (Panigrahi et al., 2018). This can prove to be especially advantageous in scenarios where frequent arterial blood gas (ABG) assessments may be unattainable or impractical, such as in neonates who are highly unwell or when being transported to a specialized neonatal intensive care facility.

This study has significant limitations. This study was conducted in one Centre, limiting its generalizability. Second, the study excluded neonates with congenital cardiac disease and metabolic problems, limiting its applicability. The sample size was statistically sufficient for the primary purpose, although a more significant, multi-center investigation would yield additional data. Finally, this was an observational study; hence, EtCO2 and ABGs' PaCO2 levels cannot be linked.

Conclusion

Our research findings indicate a robust and significant positive association between end-tidal CO2 (EtCO2) and arterial blood gases (ABGs) PaCO2 in neonates undergoing mechanical ventilation. This suggests that EtCO2 has the potential to be a dependable and less intrusive substitute for the continuous monitoring of PaCO2 in this susceptible group. The results of this study possess the capacity to provide valuable insights for developing clinical recommendations, hence improving the overall quality and effectiveness of neonatal treatment within intensive care environments.

Declarations

Data Availability statement
All data generated or analyzed during the study are included in the manuscript.

Ethics approval and consent to participate
Approved by the department Concerned.

Consent for publication
Approved

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Conflict of interest
The authors declared absence of conflict of interest.

Author Contribution

MUHAMMAD ISHAQ
Conception of Study, Development of Research Methodology Design, Review of Literature, Drafting article, Review of manuscript, final approval of manuscript
RAHMAN ULLAH
Conception of Study, Final approval of manuscript
MASROOR BIBI
Review of Literature, Drafting article
KALIM ULLAH
Study Design, Review of Literature

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