COMBINATION OF CENTRAL VENO-ARTERIAL CARBON DIOXIDE GAP WITH ARTERIO-VENOUS OXYGEN CONTENT DIFFERENCE DURING RESUSCITATION AS A PREDICTOR OF MULTI-ORGAN DYSFUNCTION IN SEPTIC PATIENTS

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ABSTRACT:

Background: *Venous-to-arterial carbon dioxide difference (Pv-aCO2) the Pcv-aCO2/arterial-to-venous oxygen content difference (Ca-cvO2) ratio may reflect the adequacy of blood flow during shock states. We sought to test whether the development of Pv-aCO2 Pcv-aCO2/arterial-to-venous oxygen content difference ratio during the very early phases of resuscitation is related to multi-organ dysfunction and outcomes in a population of septic patients resuscitated targeting the usual oxygen-derived and hemodynamic parameters.*

Aim of the Work: *To evaluate the changes in central venous-to-arterial carbon dioxide difference (Pcv-aCO$_2$ gap) and in Pcv-aCO$_2$/arterial-to-venous oxygen content difference (Ca-cvO$_2$) ratio [Pcv-aCO$_2$/Ca-cvO$_2$ ratio] during the early resuscitation in sepsis and septic shock as a predictor for development of multi-organ dysfunction and mortality.*

Patients and Methods: *This prospective observational study was performed in a 24-bed mixed ICU in a university-affiliated hospital. We examined all septic patients with a new episode admitted to the emergency room or proceeding from clinical wards during a 24-month period. After approval by Ethical Medical Committee and obtaining informed consent, simultaneous blood samples were collected from the central venous line and the arterial catheter for obtaining venous and arterial gases respectively at T0, and 6 hours (T6), 12 hours (T12) and 24 hours (T24) later. Patients were classified twice; the first one into groups (A and B) according to PcvO$_2$ gap and the second one into groups (C and D) according to Pcv-aCO$_2$/Ca-cvO$_2$ ratio. Group (A) Decreasing Pcv-aCO$_2$ (high at T0, declining at T6), Group (B) Persistently high Pcv-aCO$_2$ (high at T0 and T6), Group (C) Decreasing Pcv-aCO$_2$/Ca-cvO$_2$ ratio (high at T0, declining at T6), Group (D) Persistently high Pcv-aCO$_2$/Ca-cvO$_2$ ratio (high at T0 and T6).*

Results: *During the 24-month period, 58 septic patients older than 18 years with a new episode were screened. Patients with advanced cirrhosis (n = 4), patients with severe chronic obstructive pulmonary disease (n = 8) and pregnant women (n = 4) were not included for analysis; additionally, two patients refused the procedure. The final sample was therefore 40 patients. Our recent study found that patients with persistently high Pcv-aCO$_2$ gradient at T6 [8.64 ± 1.66] developed more organ dysfunction and have had a higher mortality rate (61.1%). This study showed that the persistently elevated Pcv-aCO$_2$/Pa-vO$_2$ ratio at time 6 was associated with a* *mortality rate of 73.7% of the patients. While decreasing of Pcv-aCO_2/ Pa-vO_2 ratio within the first 6 hours of resuscitation was associated with a survival rate of 90.5%.*

Conclusion: *Data support the hypothesis that persistence of high PCO_2 Gap and high Pcv-aCO_2/ Pa-vO_2 ratio during the early resuscitation of patients in sepsis is associated with significant higher multi-organ dysfunction and poor outcomes in critically-ill patients.*

Recommendations: *Future studies on a larger number of patients are needed and should test PCO_2 Gap and Pcv-aCO_2/ Pa-vO_2 ratio as a perfusion goal during early phases of the resuscitation of patients in septic shock to confirm its reliability.*

Key words: *Dysoxia - Septic Shock - PCO_2 gap - Pcv-aCO_2/ Pa-vO_2 ratio -Organ Dysfunction - Clinical Outcome*

INTRODUCTION:

Inadequate tissue perfusion is a factor in the pathogenesis and clinical course of multi-organ failure in the critically ill. Current techniques for monitoring tissue perfusion have largely focused on systemic blood flow and the balance between oxygen demand and supply. An early hemodynamic optimization that targets central venous oxygen saturation (ScvO2) and systemic hemodynamic parameters improves outcomes in severe sepsis and septic shock reinforcing the idea that tissue perfusion abnormalities are flow dependent at least during the very early stages. However, normalizing systemic hemodynamic parameters does not guarantee adequate tissue perfusion, and in fact a substantial number of patients still progress to multi-organ dysfunction and death despite meeting ScvO2 targets(1).

Moreover, some studies demonstrate that oxygen-derived parameters such as central venous oxygen saturation ($ScvO_2$) are commonly normalized at ICU admission and maneuvers such as emergent intubation can quickly improve $ScvO_2$ despite regional and tissue perfusion derangements(2).

In the past, authors described the coexistence of venous acidemia and increased venous carbon dioxide (CO_2) during cardiac arrest in both animals and critically ill humans. Thereafter, increases in the venous-to-arterial carbon dioxide difference (Pcv-aCO_2) were reported during hypovolemic, cardiogenic, obstructive, and septic shock. Interestingly, an inverse curvilinear relationship between Pcv-aCO_2 and cardiac output was described, highlighting the importance of blood flow on venous CO_2 accumulation. Pcv-aCO_2 thus aroused clinical interest as a marker of global perfusion during shock states(3).

Other data suggest that high Pcv-aCO_2 could identify septic patients who remain inadequately resuscitated despite achieving oxygen metabolism targets, reinforcing the notion of Pcv-aCO_2 as a marker of global perfusion due to its ability to track blood flow alterations or even detect anaerobic CO_2 generation(4) .

Furthermore, patterns of recovery or derangement of Pcv-aCO_2 during very early stages of resuscitation of septic shock have not been widely described and recent studies trying to demonstrate the reliability of Pcv-aCO_2 as a tool in resuscitation of septic patients could have been influenced by selection bias because not all potential patients were elected to catheter insertion and goal-directed therapy**(5)**.

In addition, some authors have suggested that correcting the Pcv-aCO_2 gap by an approximation of the oxygen consumption, the Pcv-aCO_2/arterial-to-venous oxygen content difference ($Ca\text{-}cvO_2$) ratio, might be superior to the $Pcv\text{-}aCO_2$ gap to detect anaerobic metabolism, and there-fore should be a more reliable parameter to guide the resuscitation process[(6)].

PATIENTS AND METHODS:

This prospective observational study was performed in a 24-bed mixed ICU in a university-affiliated hospital. We examined all septic patients with a new episode admitted to the emergency room or proceeding from clinical wards during a 24-month period. Patients were excluded if they were younger than 18 years old, pregnant, had severe chronic obstructive pulmonary disease, advanced liver cirrhosis (Child–Pugh C), chronic renal failure on regular dialysis, Patients with Pcv-aCO2 gap less than 6 mmHg, Patients with Pcv-aCO2/Ca-cvO2 ratio less than 1.4 and Patients already enrolled in another study

General management:

All patients were evaluated by the Intensive Care Unit rapid response team according to our local procedures. Each patient was equipped with an arterial cannula and a central venous catheter. Our early goal-directed therapy included a bundle of interventions that sought to obtain: mean arterial pressure ≥65 mmHg; urine output ≥0.5 ml/kg/minute; normalization of serum lactate; and ScvO2 ≥70% The use of vasopressors was standardized to maintain a mean arterial pressure ≥65 mmHg, and repeated fluid challenges with crystalloids or colloids were used to optimize the stroke volume as well as to allow the lowest dose of vasopressors. Dobutamine was added for persistent ScvO2 ≤70% after fluid resuscita-tion if hematocrit was less than 30%. A low dose of 50 mg of hydro-cortisone was given within 6 hours of resuscitation when use of vasopressors persisted after an adequate fluid restitution. Mechanical ventilation was provided when needed under light sedation (midazolam) and analgesia (fentanyl); the tidal volume was limited to 6 to 8 ml/kg. Finally, stress ulcer and venous thrombosis prophylaxis were provided according to international recommendations.

Study protocol:

This study was done after approval by Ethical Medical Committee and obtaining informed consent. A written informed consent was waived because no new therapeutic interventions were performed and all measurements and procedures routinely followed the local protocols for the management of septic patients. Simul-taneous blood samples were collected from the central venous line and the arterial catheter for obtaining venous and arterial gases respectively and also lactate measurements at T0, and 6 hours (T6), 12 hours (T12) and 24 hours (T24) later. Measured variables included arterial oxygen tension (PaO_2), arterial carbon dioxide tension ($PaCO_2$), central venous oxygen tension ($PcvO_2$), central venous carbon dioxide tension ($PcvCO_2$), arterial oxygen saturation (SaO_2) and central venous oxygen saturation ($ScvO_2$). Furthermore, SOFA Score was measured daily.

$Pcv\text{-}aCO_2$ was defined as the difference between the central venous CO_2 partial pressure and the arterial CO_2 partial pressure.The arterial oxygen content (CaO_2), central venous oxygen content ($CcvO_2$), arterial-venous oxygen content difference ($Ca\text{-}cvO_2$), and $Pcv\text{-}aCO_2/Ca\text{-}cvO_2$ ratio were calculated according to the following formulas:[(7)]

$$CaO_2 = (1.34 \times SaO_2 \times Hb) + (0.003 \times PaO_2)$$

$$CcvO_2 = (1.34 \times ScvO_2 \times Hb) + (0.003 \times PcvO_2)$$

$$Ca\text{-}cvO_2 = CaO_2 - CcvO_2$$

$$Pcv\text{-}aCO_2 \text{ gap} = PcvCO_2 - PaCO_2$$

$$Pcv\text{-}aCO_2/Ca\text{-}cvO_2 \text{ ratio} = Pcv\text{-}aCO_2/Ca\text{-}cvO_2$$

Patients were classified twice; the first one into groups (A and B) according to $PcvO_2$ gap and the second one into groups (C and D) according to Pcv-aCO_2/Ca-cvO_2 ratio. Group (A) Decreasing Pcv-aCO_2 (high at T0, declining at T6), Group (B) Persistently high Pcv-aCO_2 (high at T0 and T6), Group (C) Decreasing Pcv-aCO_2/Ca-cvO_2 ratio (high at T0, declining at T6), Group (D) Persistently high Pcv-aCO_2/Ca-cvO_2 ratio (high at T0 and T6)

Data analysis:

Data were collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) version 23. The quantitative data were presented as mean, standard deviations and ranges when parametric and median with inter-quartile range (IQR) when non parametric and percentiles were used to assess the distribution of some parameters. Also, qualitative variables were presented as number and percentages.

The comparison between groups regarding qualitative data was done by using ***Chi-square test*** and/or ***Fisher exact test*** when the expected count in any cell found less than 5.The comparison between two independent groups with quantitative data and parametric distribution was done by using ***Independent t-test*** while with non-parametric distribution was done by using ***Mann-Whitney test.*** Also, receiver operating characteristic curve (ROC) was used to assess predictors of mortality at 28 day with its sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and area under curve (AUC). The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following: P-value > 0.05: Non significant (NS), P-value < 0.05: Significant (S), P-value < 0.01: Highly significant (HS)

RESULTS:

During the 24-month period, 58 septic patients older than 18 years with a new episode were screened. Patients with advanced cirrhosis (*n* = 4), patients with severe chronic obstructive pulmonary disease (*n* = 8) and pregnant women (*n* = 4) were not included for analysis; additionally, two patients refused the procedure. The final sample was therefore 40 patients.

Patients' characteristics of group A and B showed no statistically significant difference between the two groups regarding gender and age (Table 1).

Table (1): Patient's characteristics of groups A and B:

		Group A	Group B	P-value	Sig.
		No. = 22	No. = 18		
Gender	Females (Number and %)	13 (59.1%)	13 (72.2%)	0.386*	NS
	Males (Number and %)	9 (40.9%)	5 (27.8%)		
Age (years)	Mean ± SD	66.27 ± 12.38	67.28 ± 11.34	0.792•	NS

The need of inotropes was 16 (72.7%) Vs. 16 (88.9%) in groups A and B respectively and mechanical ventilation was 8 (36.4%) Vs. 12 (66.7%) in groups A and B respectively. There no statistically significant difference between groups (A & B) regarding need of inotropes and mechanical ventilation (Diagram 1).

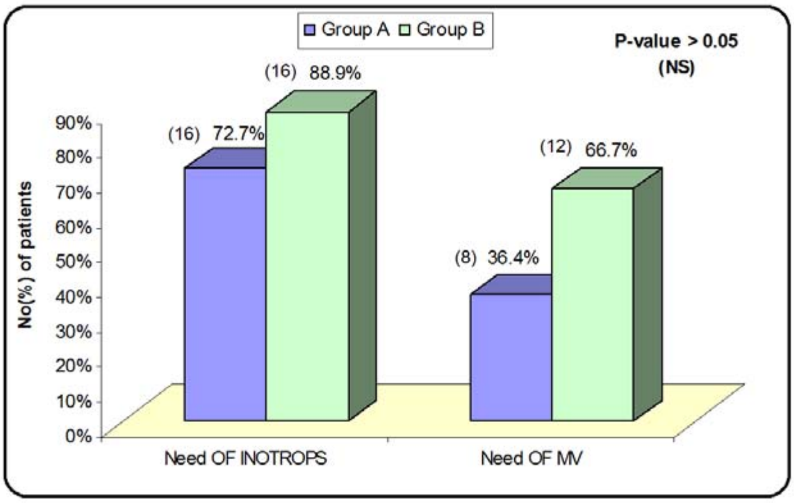

Diagram (1): Need of Inotropes and Mechanical ventilation in groups A and B.

The number of organs dysfunction was significantly lower in **group A** (2.20±1.57) compared to group B (3.93±1.77) (Table 2). The total length of stay was comparable between the two groups (7.55±4.52) in group A and (8.33±5.03) in group B (Table 2). However, mortality was significantly higher in group B 11(61.1%) compared to group A 6(22.7%) (Table 2). Number of organs dysfunction was compared between groups A and B Diagram 2) with more patients in group A suffering from one organ dysfunction 8 (36.4%) while more patients in group B suffered 5 organ dysfunctions 5 (27.8%).

Table (2): Number of Organ dysfunction, length of total stay and mortality in groups A and B:

		Group A	Group B	P-value	Sig.
		No. = 22	No. = 18		
Number of organs dysfunction	Mean ± SD	2.20 ± 1.57	3.93 ± 1.77	0.010•	S
Length of total stay (days) (Intensive care unit and hospital stay)	Mean ± SD	7.55 ± 4.52	8.33 ± 5.03	0.605•	NS
Mortality at 28 day (Number and %)		5 (22.7%)	11 (61.1%)	0.014*	S

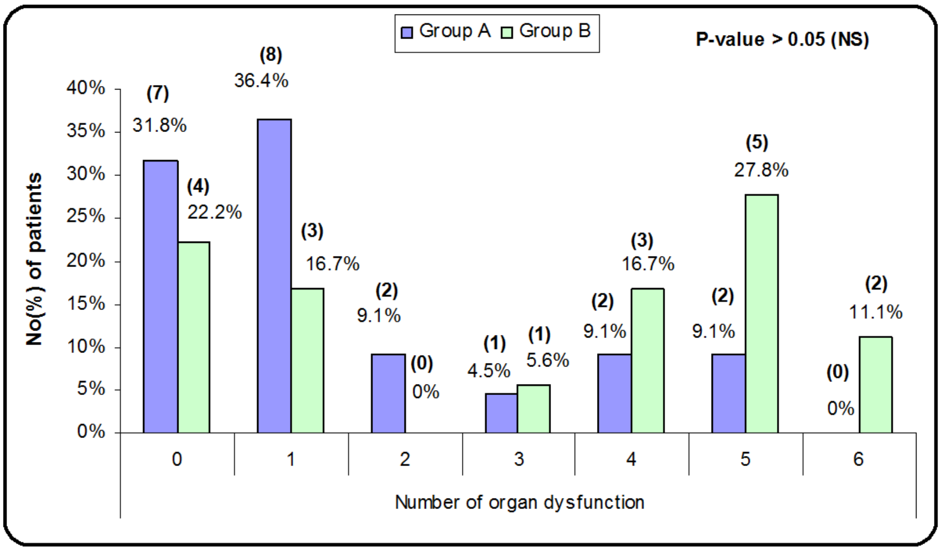

Diagram (2): Number of Organ dysfunction in groups A and B.

SOFA Score in groups A and B showed statistically significance difference on the 3rd day being significantly lower in group A {4.5(3-7)} than in group B {8(3-12)} (Diagram 3)

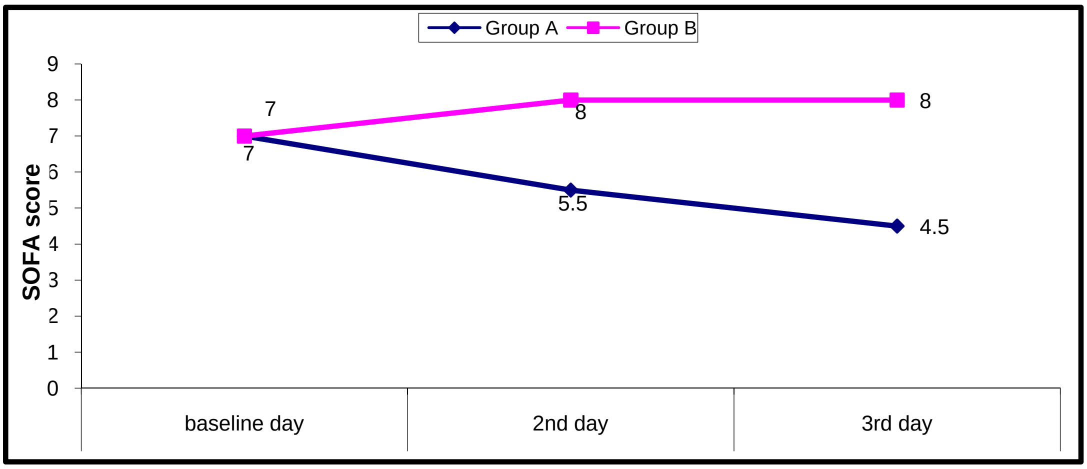

Diagram (3): SOFA Score distribution in groups A and B.

Also, for the two groups C and D, there was no statistically significant difference between the two groups regarding gender and age (Table 3). Group C and D showed comparable results in the need of inotropes. it was 15(71.4%) Vs. 17 (89.5%) in groups C and D respectively. However, the need of mechanical ventilation was significantly higher in group D 14(73.3%) compared to group C 6(28.6%) (Diagram4).

Table (3): Patients characteristics in group C and D:

		Group C	Group D	P-value	Sig.
		No. = 21	No. = 19		
Gender	Females (Number and %)	13 (61.9%)	13 (68.4%)	0.666	NS
	Males (Number and %)	8 (38.1%)	6 (31.6%)		
Age (years)	Mean ± SD	64.00 ± 11.27	69.74 ± 11.89	0.126	NS

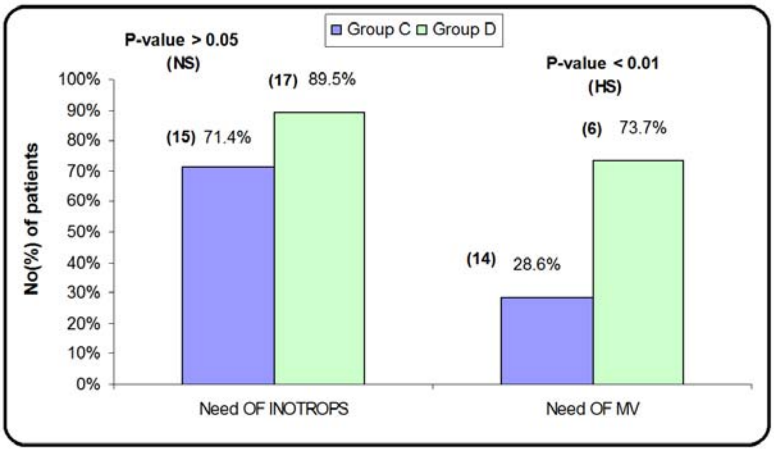

Diagram (4): Need of inotropes and need of mechanical ventilation in group C and D.

The number of organs dysfunction was significantly lower in group C (1.62±1.19) compared to group D (4.19±1.47), also the mortality was significantly lower 2(9.5%) in group C versus 14(73.3%) in group D (Table 3). More patients in group C suffered from one organ dysfunction 9(42.9%) while more patients in group D suffered from 5 organ dysfunction 6(31.6%) (Diagram 5).

Table (4): Number of Organs dysfunction, length of total stay and mortality in group C and D:

		Group C No. = 21	Group D No. = 19	P-value	Sig.
Number of Organ dysfunction	Mean ± SD	1.62 ± 1.19	4.19 ± 1.47	0.000•	HS
Length of stay (days) (Intensive care unit and hospital stay)	Mean ± SD	8.19 ± 4.55	7.58 ± 4.99	0.687•	NS
Mortality at 28 day (Number and %)		2 (9.5%)	14 (73.7%)	0.000/	HS

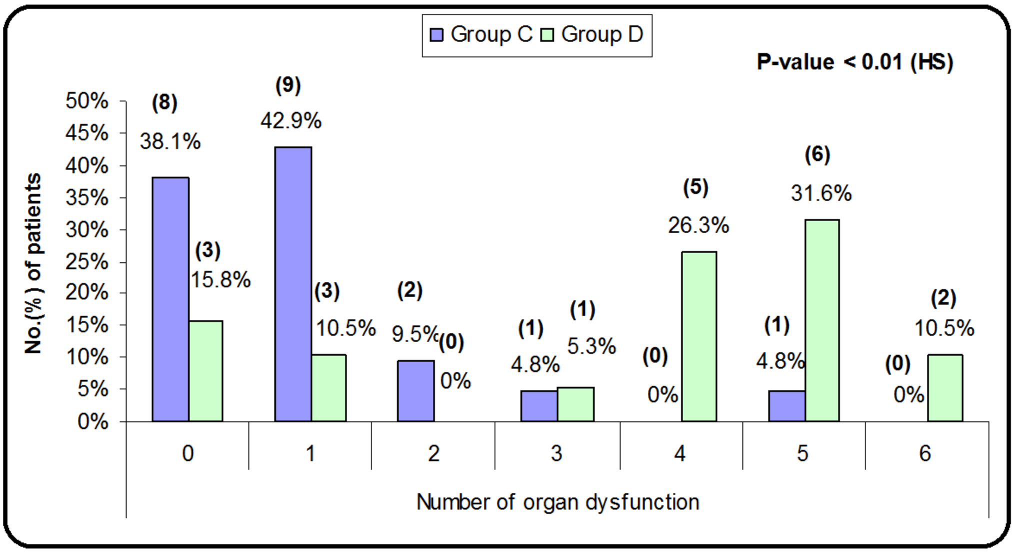

Diagram (5): Distribution of organ dysfunction in group C and D.

SOFA Score in group C and D showed statistically significance difference on the 3rd day being significantly lower in group C {4(3-7)} than in group D {10(3-12)} (Diagram 6).

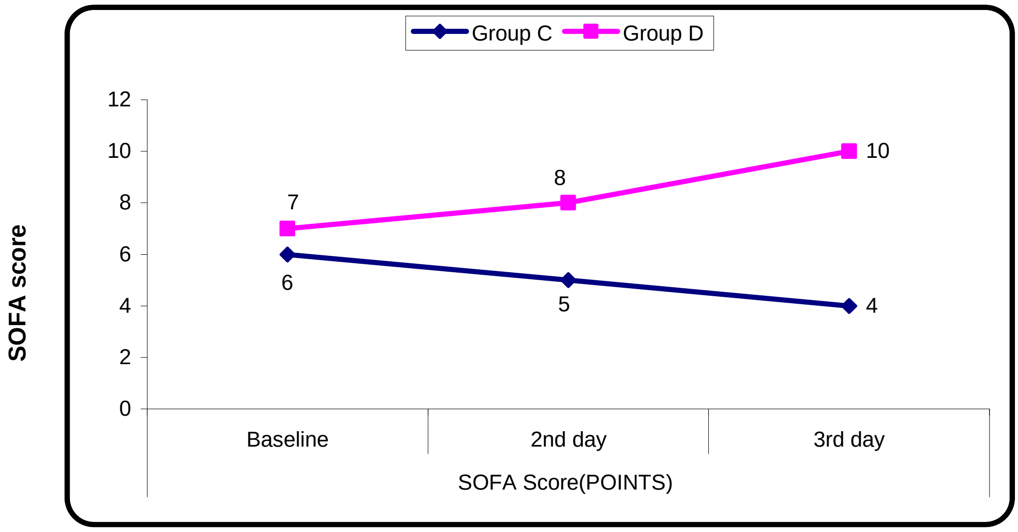

Diagram (6): SOFA Score in group C and D.

Pcv-aCO_2 Gap had diagnostic performance in prediction of death, with sensitivity 100%, 87.5%, 76.9% at T6 , T12, T24 respectively and specificity 50% , 75%, 82.4% at T6 , T12, T24 respectively (Table 5 and Diagram 7).

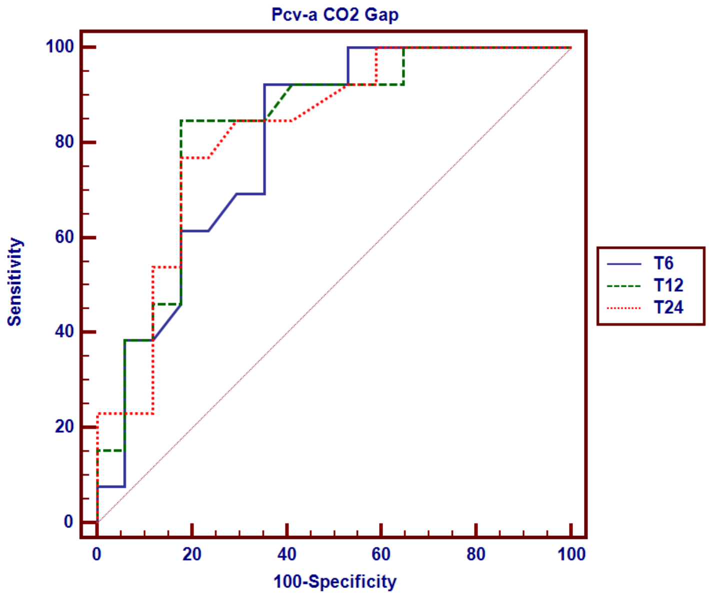

Diagram (7): Receiver operating characteristic curve (ROC) for Pcv-a CO_2 Gap at T6 and T12 as predictors for mortality

Table (5): Receiver operating characteristic curve (ROC) for Pcv-a CO_2 Gap at T6 and T12 as predictors for mortality

	Cut off point	AUC	Sensitivity	Specificity	PPV	NPV
T6	>6	0.773	100	50	57.1	100
T12	>6.4	0.852	87.5	75	70	90
T24	> 5.9	0.821	76.9	82.4	76.9	82.4

Pcv-aCO_2/ Ca-cvO_2 ratio had perfect diagnostic performance in prediction of death, with sensitivity 81.25%, 100%, 93.75% at T6, T12, T24 respectively and specificity 83.33%, 66.67%, 37.5% at T6, T12, and T24 respectively(Table 6 and Diagram 8).

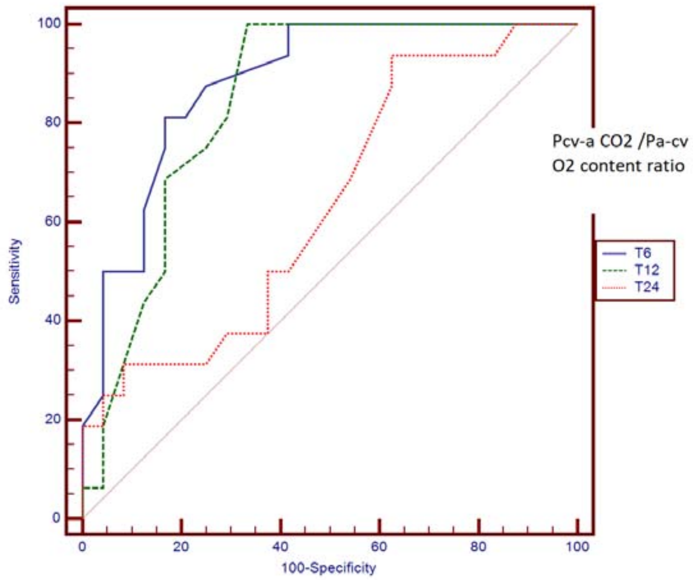

Diagram (8): Receiver operating characteristic curve (ROC) for Pcv-aCO_2/Ca-cvO_2 ratio at T6, T12 and T24 as predictors for mortality.

Table (6): Receiver operating characteristic curve (ROC) for Ratio at T6 and T12 and T24 as predictors for mortality

	Cut off point	AUC	Sensitivity	Specificity	PPV	NPV
T6	>1.9	0.883	81.25	83.33	76.5	87.0
T12	>1.6	0.845	100.00	66.67	66.7	100.0
T24	>1.3	0.637	93.75	37.50	50.0	90.0

DISCUSSION:

We studied a cohort of patients during the very early phases of septic shock who were subjected to a comprehensive resuscitation aimed to target the usual hemodynamic and oxygen metabolism parameters. Our study found that patients with persistently high Pcv-aCO_2 gradient at T6 [8.64 ± 1.66] developed more organ dysfunction and have had a higher mortality rate (61.1%).

In concordance with our study**,** *Ospina and his colleagues* studied 108 patients with septic shock, they measured Pcv-aCO_2 gradient at time 0 and after 6 hours, they found that those with persistently high Pcv-aCO_2 gradient at T6 [7.0 (5.8 to 9.7)] developed more organ dysfunction assessed by SOFA score at day-3 (P <0.001), than patients evolving with normal Pcv-aCO_2 gradient during the first 6 hours of resuscitation [4.4 (2.7-5.4]. Additionally, they observed that persistently high Pcv-aCO_2 gradient were associated with a lower survival at day-28 [(9)].

Similar to our results, *Van Beest and his colleagues* recruited 60 patients with septic shock. They measured Pcv-aCO_2 gradient at time 0 and after 6 hours. They found a higher Pcv-aCO_2 gradient at Time 0 (6.5±3.0 vs. 3±1.8, P <0.001) and Time 6 (8±4 vs. 3±2, P <0.001) in non survivors vs. survivors respectively[(5)].

On the other hand, a study done by *Machado and his colleagues* on 43 patients with severe sepsis and septic shock found that SOFA Time 0, and SOFA Time 24 hour scores were 7.9 ± 3.8, and 8.0 ± 4.3, respectively. ΔCO2 at T0 (P = 0.60) and its trend (P = 0.36) are not related to ΔSOFA. The analysis of SvcO2 also showed no significant finding. So ΔPCO2 and SvcO2 and its increasing trends in first 24 hours are unrelated to the SOFA score which was insignificant with mortality, which may be related to lower number of patients included in the study[(8)].

Regarding Pcv-aCO2/ Pa-vO2 ratio:

Our study showed that the persistently elevated Pcv-aCO_2/ Pa-vO_2 ratio at time 6 was associated with a mortality rate of 73.7% of the patients. While decreasing of Pcv-aCO_2/ Pa-vO_2 ratio within the first 6 hours of resuscitation was associated with a survival rate of 90.5%.

Monnet and his colleagues found that ratio of the central venous-to-arterial CO_2 tension difference (ΔPCO_2) over the arterial-to-venous oxygen content difference (ΔContO_2), predicted an increase in VO_2 after a fluid-induced increase in DO_2 and thus, can be able to detect the presence of global tissue hypoxia[(10)].

Our study supports the notion that serial measurements of the Pcv-aCO_2/ Pa-vO_2 ratio during resuscitation may serve as surrogate markers of the payment of the oxygen debt.

It was also observed in our study that Pcv-aCO_2/ Pa-vO_2 ratio is superior to Pcv-aCO_2 in detecting organ dysfunction and mortality.

In concordance with our study *Huai-wu and his colleagues* found that The Pcv-aCO_2 gap and Pcv-aCO_2/ Pa-vO_2 ratio were significantly and negatively related to the lactate clearance[(11)].

Mallat and his colleagues studied eighty patients with septic shock and found that decreasing Lactate level alone was an independent predictor of 28-day mortality. Also, they found that Monitoring PCO2 may be a useful tool to assess the adequacy of tissue perfusion during resuscitation in combination with lactate level[(12)].

conclusion and recommendations

Data support the hypothesis that persistence of high PCO_2 Gap and high Pcv-aCO_2/ Pa-vO_2 ratio during the early resuscitation of patients in sepsis is associated with significant higher multi-organ dysfunction and poor outcomes in critically-ill patients.

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إستخدام الفارق بين ضغط ثاني اكسيد الكربون الوريدي المركزي الشرياني والفارق بين محتوي الاكسجين الشرياني- الوريدي خلال الانعاش كعامل تنبؤي لخلل الاعضاء الوظيفي في مرضي الإصابة التسممية

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**قسم حالات حرجة بجامعة القاهرة منتدب بجامعة مصر للعلوم والتكنولوجيا

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مقدمة: يعتبر زيادة فرق ضغط الدم الوريدي- الشرياني لثاني اكسيد الكربون علامة قيمة علي نقص أكسجة الانسجة في حالات الصدمة (نقص الاكسجة الدماغية) المصحوبة بانخفاض النتاج القلبي لما لها من علاقة عكسية مع مؤشر القلب. تشير البيانات الأخيرة أن ارتفاع فرق ضغط الدم الوريدي- الشرياني لثاني اكسيد الكربون يساعد في تحديد مرضى الصدمة التسممية الذين لم يتم انعاشهم بشكل كاف على الرغم من تحقيق أهداف عملية ايض الأكسجين، كما يتم اتهام الخلل في أكسجة الانسجة بشكل عام او بشكل موضعي بانة السبب في فشل العديد من أجهزة الجسم وبالنظر إلى نسبة الفرق بين محتوي الاكسجين الشرياني الوريدي علي ضغط الدم الوريدي- الشرياني لثاني اكسيد الكربون يمكن ان يتبع كعلامة لاكسجة الجسم خلال حالات الصدمة المختلفة. فقد وجد ان زيادة فرق ضغط الدم الوريدي- الشرياني لثاني اكسيد الكربون و الفرق بين محتوي الاكسجين الشرياني الوريدي علي ضغط الدم الوريدي- الشرياني لثاني اكسيد الكربون مرتبط بفشل الاعضاء وزيادة معل الوفيات لمرضي الحالات الحرجة.

الهدف من العمل: تهدف هذة الرسالة الي تقييم قيمة التغير في فرق ضغط الدم الوريدي- الشرياني لثاني اكسيد الكربون و الفرق بين محتوي الاكسجين الشرياني الوريدي خلال الإنعاش في مرضى التسمم الشديد والصدمة التسممية باعتباره مؤشرا لحدوث اختلال وظيفي للأعضاء وايضا معدل الوفيات.

المرضى وطرق البحث: تم تنفيذ هذه الدراسة في قسم وحدة العناية المركزة في مستشفى التعليمي بجامعة مصر للعلوم والتكنولوجيا.تألفت دراستنا من ٤٠ مريضا تم حجزهم في وحدة العناية المركزة يعانون من انتان بالدم، وانتان شديد بالدم وصدمة انتانيه .تم الحصول على عينة الدم الشريانيه والوريديه المركزيه في وقت واحد لحساب الفرق فى الضغط الوريدى والشريانى لغاز ثانى اكسيد الكربون ، ونسبة الفرق بين محتوي الاكسجين الشرياني الوريدي علي ضغط الدم الوريدي- الشرياني لثاني اكسيد الكربون واللاكتات في وقت دخول المريض ،وبعد ٦ ساعات،و ١٢ ساعة و ٢٤ ساعة .ثم تمت متابعة المرضى عن طريق SOFA score لتقييم فشل الأعضاء ,وتم حساب الوفيات في اليوم الثامن والعشرين.

النتائج: كشفت نتائجنا أن هناك علاقة قوية بين الفرق فى الضغط الوريدى والشريانى لغاز ثانى اكسيد الكربون ، ونسبة الفرق بين محتوي الاكسجين الشرياني الوريدي علي ضغط الدم الوريدي- الشرياني لثاني اكسيد الكربون ونتائج المرضى وهذا يخلص أن نسبة الفرق بين محتوي الاكسجين الشرياني الوريدي علي ضغط الدم الوريدي- الشرياني لثاني اكسيد الكربون يمكن ان تستخدم كأداة ممتازه في التنبؤ بالوفاه.

الملخص والتوصيات : نسبة الفرق بين محتوي الاكسجين الشرياني الوريدي علي ضغط الدم الوريدي- الشرياني لثاني اكسيد الكربون يمكن ان يكون افضل من الفرق فى الضغط الوريدى والشريانى لغاز ثانى اكسيد الكربون كأداة ممتازة في التنبؤ بالوفاه.