TURKISH JOURNAL OF EMERGENCY MEDICINE

Original Article

Access this article online

Quick Response Code:

Website:
https://turkjemergmed.com/

DOI:
10.4103/tjem.tjem_223_24

The utility of monitoring end-tidal carbon dioxide in emergency department to predict inhospital mortality of patients presenting with nontraumatic shock: A prospective observational study

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Submitted: 23-10-2024
Revised: 16-02-2025
Accepted: 18-02-2025
Published: 01-07-2025

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Abstract:

OBJECTIVES: We aimed to identify the ability of end-tidal carbon dioxide (EtCO2) to predict inhospital mortality of patients presenting to the emergency department (ED) with nontraumatic circulatory shock. We also attempted to assess the correlation between EtCO2 and other traditional vital signs and laboratory parameters in this patient population at different time points during their resuscitation.

METHODS: This was a single-center prospective observational study conducted among patients with nontraumatic circulatory shock who presented to the ED of a tertiary care teaching institute in India. EtCO2 measurement was done using mainstream capnography in both intubated and nonintubated patients at presentation and at 120 min of resuscitation. Heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure (MAP), respiratory rate, oxygen saturation, and laboratory parameters (lactate, base deficit [BD], and partial pressure of carbon dioxide) were measured at the same time points. All patients were followed up till hospital discharge.

RESULTS: One hundred and ten patients were recruited to the study. An EtCO2 of $\leq$ 23 mm Hg at presentation was 87% sensitive (95% CI: 73-95 %) and 43% specific (95% CI: 31-56 %) in predicting in-hospital mortality of patients presenting with no-traumatic circulatory shock in emergency department [area under curve (AUC): 0.735 (95% CI: 0.638-0.832, p<0.001)]. EtCO2 $\geq$23 mmHg at presentation had a significant predictive value on the risk of in-hospital mortality with an adjusted odd's ratio of 0.08 (95% CI: 0.02–0.3, P < 0.001). EtCO2 values at presentation and 120 min as well as the change between the time points showed statistically significant weak-to-moderate positive correlations with corresponding values of MAP and BD. Similarly, a significant negative correlation was demonstrated with lactate levels at the same time points.

CONCLUSION: EtCO2 values at presentation are an independent predictor of inhospital mortality of patients with circulatory shock of nontraumatic etiology presenting to the ED.

Keywords:

Capnography, emergency department, inhospital mortality, shock

How to cite this article: Abhiraj R, Ekka M, Sreekumar A, Aggarwal P, Jamshed N, Bhoi SK, *et al*. The utility of monitoring end-tidal carbon dioxide in emergency department to predict inhospital mortality of patients presenting with nontraumatic shock: A prospective observational study. Turk J Emerg Med 2025;25:199-207.

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Box-ED section

What is already known on the study topic?
- End-tidal carbon dioxide (EtCO2) monitoring reliably predicts mortality among patients with traumatic hemorrhagic shock.

What is the conflict on the issue? Has it importance for readers?
- The role of EtCO2 monitoring to predict inhospital mortality among patients with circulatory shock of nontraumatic etiology remains uncertain
- EtCO2 may be explored as a continuous, noninvasive, and dynamic monitoring tool in patients presenting with nontraumatic shock to the emergency department (ED).

How is this study structured?
- This was a single-center, prospective observational study that included data from 110 patients.

What does this study tell us?
- EtCO2 at presentation is a significant independent predictor of inhospital mortality in patients with circulatory shock of nontraumatic etiology
- EtCO2 may be considered for use as a monitoring modality for guiding resuscitation in this patient population in ED.

Introduction

Shock is a state of global hypoperfusion leading to life-threatening organ dysfunction, which stems from either reduced cardiac output or reduced effective circulatory blood volume. Shock is an extremely common presentation to the emergency department (ED), with population-based cohort studies showing an incidence of 63.2–76 per 100,000 person years.[1,2] Irrespective of the etiology, shock is invariably associated with poor outcomes with studies estimating a substantial 7-day and 90-day mortality of 23.1% and 40.7%, respectively, despite best resuscitative measures.[2] This makes its early recognition and appropriate management mandatory and possibly life-saving. Traditional clinical parameters used to evaluate and monitor patients with shock include heart rate (HR), systolic and diastolic blood pressures (SBP and DBP), mean arterial pressure (MAP), and respiratory rate (RR). However, these parameters have since been shown to have relatively limited utility for the same, especially in the early stages of shock where they may be falsely reassuring.[3,4] Blood lactate levels and base deficit (BD) are the usual laboratory parameters used for monitoring shock patients. These tests, however, require repeated blood sampling for serial monitoring.

Capnography is a noninvasive technique which measures the partial pressure or maximum concentration of carbon dioxide in exhaled air, at the end of an expiration. End-tidal carbon dioxide (EtCO2) is a dynamic measure of a patient's metabolic, circulatory, and ventilatory status.[5] In patients with stable metabolic and ventilatory functions, it reflects the real-time microcirculatory state of the patient and has been shown in a few studies to correlate with serum lactate, fluid responsiveness, cardiac output, and perfusion pressures.[6-12] EtCO2 has been shown to be highly sensitive to changes in the microcirculation in real time, making it an ideal tool to identify early circulatory insufficiency. It is also noninvasive, making it ideal for continuous dynamic monitoring of these patients.

However, most of the literature regarding the utility of EtCO2 in shock has been performed in patients with hemorrhagic shock following trauma, with little literature on other etiologies of shock. Studies in nonintubated spontaneously breathing patients have also been limited due to the relatively rare use of sidestream or microstream capnometer in the ED. Considering these lacunae in the existing literature, we conducted a prospective observational study to assess the ability of EtCO2 in monitoring and prognostication of patients presenting to the ED with shock of nontraumatic etiology.

Methods

Study design

It was a single-center prospective observational study in the ED of a tertiary care teaching hospital in North India. The study was conducted from September 2021 to February 2023. The study protocol was reviewed and approved by the Institute Ethics Committee of AIIMS, Delhi (Approval number: IECPG/554/23.09.2021).

Selection of participants

Patients aged 18 years or above presenting to the emergency with circulatory shock of nontraumatic etiology were recruited in the study. Patients were defined to be in circulatory shock if they had a MAP ≤65 mmHg with two or more of the following signs of hypoperfusion-confusion/obtundation, cold and clammy extremities, lactate ≥4 mmol/L, BD ≤−4 mEq/L, and oliguria.

Patients who had received resuscitation before arrival to the ED from other hospitals, who presented to the ED in cardiac arrest, and those who had complex pulmonary pathologies such as pulmonary embolism, pulmonary hypertension, and obstructive airway disease were excluded from the study. Patients who had advanced directives for "Do not resuscitate" were also excluded from the study.

Sample size calculation

Based on the study conducted by Kheng and Rahman comparing early mean EtCO2 with the outcome of patients with circulatory shock, with 80% power and taking α as 0.05, the sample size for our study was calculated to be 110 patients.[3]

Data collection and measurements

Patients in shock fulfilling the inclusion criteria were enrolled into the study after taking written informed consent from the patients themselves or from their legally authorized representative. Data including demographic profile, comorbid diseases, presenting complaints, cause of shock, type of shock, intubation status, and disposition were collected in a predesigned questionnaire. One milliliter heparinized blood samples were drawn for estimation of partial pressure of carbon dioxide (PaCO2), lactate, and BD at 0 and 120 min of presentation. Analysis was done using Radiometer AQT90 Flex Analyzer (Radiometer Medical Aps, Brønshøj, Denmark). Vital signs (HR, SBP and DBP, MAP, and RR) and EtCO2 were recorded at time 0 and at 120 min. All patients were managed as per the standard guidelines by the ED team. Patients were followed up till discharge from the hospital.

Mainstream capnography through intubated adapters by Nihon Kohden, America, TG 920P and nonintubated adapters by Nihon Kohden, America, YG-122T were used for recording EtCO2 in intubated and nonintubated patients, respectively. The capnometer probe was connected to the airway circuit in intubated patients and to an oronasal sampling cannula in nonintubated patients [Figure 1]. The EtCO2 value was measured at

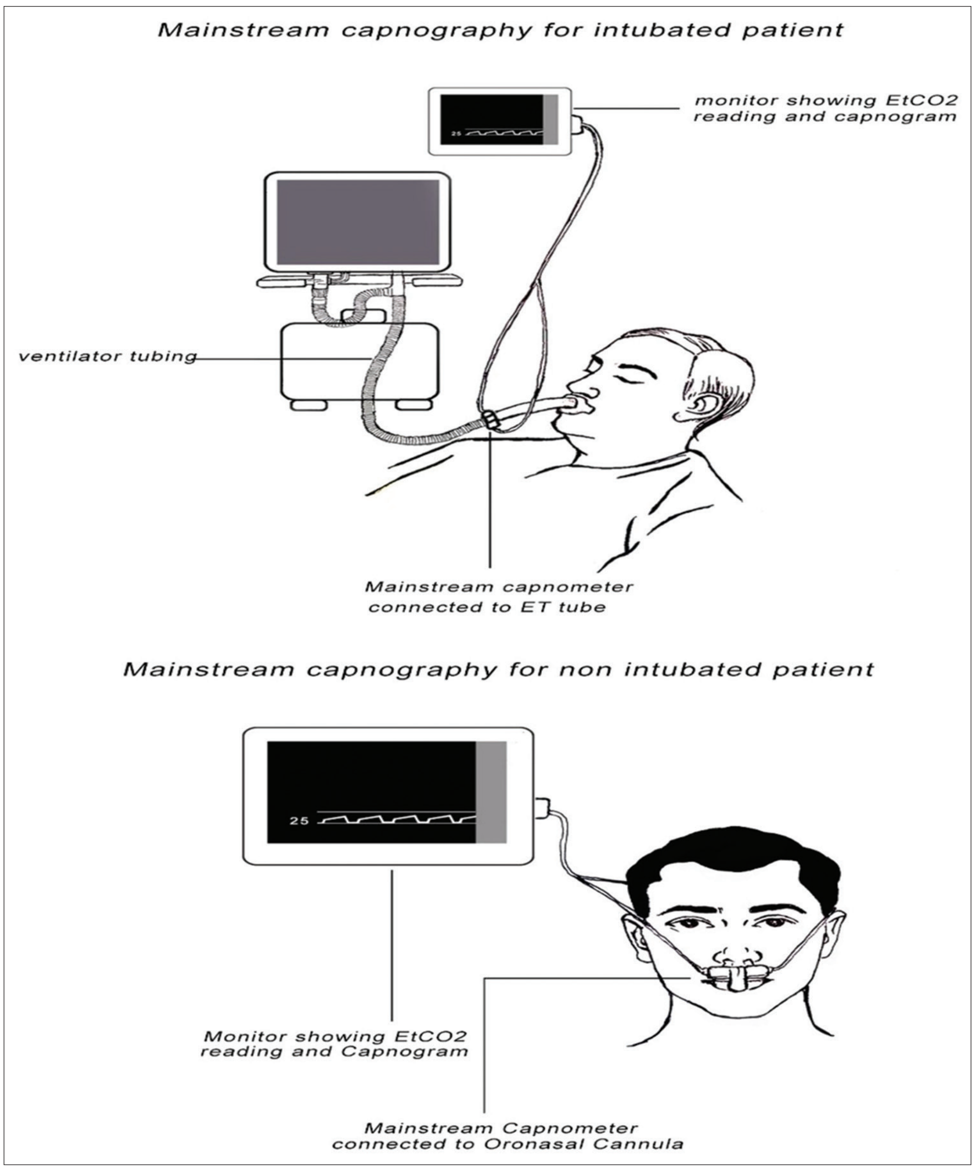


Figure 1: Illustration of set-up of mainstream capnography in intubated and nonintubated patients. EtCO2: End-tidal carbon dioxide, ET tube: Endotracheal tube

6 breaths after initiation of capnography monitoring. The capnometers used work on the principle of infrared absorption spectroscopy using an airway adapter connected to the breathing circuit.[3-5]

Outcome measures

Our primary objective was to study the ability of EtCO2 to predict inhospital mortality in patients presenting to the ED with nontraumatic circulatory shock for which we calculated the area under the receiver operating characteristic curve (AUROC) and odds ratio (OR) of EtCO2 against inhospital mortality. Our secondary objective was to assess the correlation between EtCO2 and lactate, MAP, and BD in this patient population at different time points during their resuscitation, calculated by the respective Pearson's correlation coefficients.

Statistical analysis

Data was summarised and analysed using IBM SPSS Statistics for Windows (version 24.0, IBM Corporation, Armonk, New York, United States). Quantitative data were expressed as mean ± standard deviation if continuous in distribution, or median and interquartile range if discontinuous. Qualitative data were expressed as counts and percentages. Independent samples *t*-test was used to compare the values between survival and nonsurvival groups. Chi-square/Fischer's exact test was used to compare categorical data. Receiver operating curve (ROC) analysis of individual parameters to predict inhospital mortality was performed and De Long's test was used to assess whether the differences in AUROCs of individual parameters were statistically significant at different time points. Youden's *J*-test was performed to assess the optimal cutoff of EtCO2 to predict inhospital mortality. EtCO2 was converted into a categorical variable using the cutoff decided from ROC analysis before entering the logistic regression model. The OR was adjusted for covariates (age, sex, MAP, lactate, and BD) to determine the independent effect of EtCO2 on inhospital mortality. The changes in values of EtCO2, lactate, MAP, and BD from presentation to 120 min were recorded as delta EtCO2, delta lactate, delta MAP, and delta BD, respectively. Pearson's correlation analysis was performed to establish the correlation between EtCO2 and these parameters at both time points, as well as their corresponding deltas. A two-tailed $P < 0.05$ was considered statistically significant.

Results

A total of 238 patients presenting to the ED with shock were screened, of which 110 patients were enrolled in the study, out of which 60 (54.55%) were males. The recruitment of the study population is shown in Figure 2. The mean age of the study participants was 46 ± 15.5 years. The clinical characteristics of the study participants are described in Table 1. Forty-six patients (41.82%) died during the hospital course while the rest survived to hospital discharge.

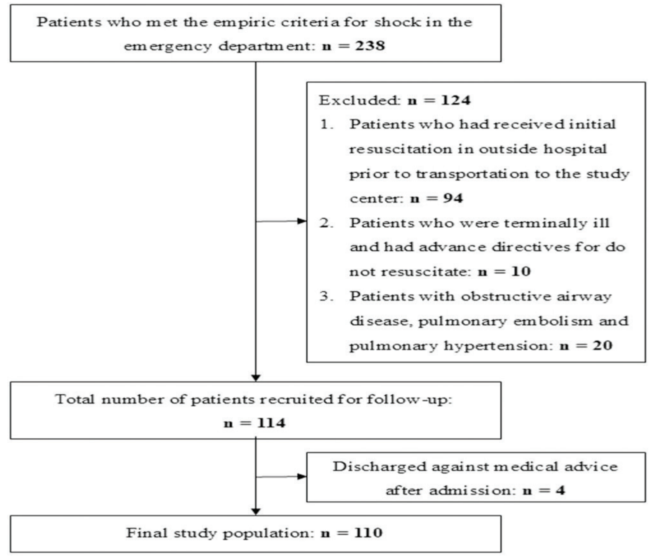


Figure 2: Recruitment of study participants

Septic shock was the most common presentation among the patient population (40.91%), followed by hypovolemic (30%) and cardiogenic shock (17.27%) [Table 1].

The mean EtCO2 values at 0 min differed significantly between the patients who survived till hospital discharge and those who did not (22.2 ± 3.3 mmHg vs. 18.3 ± 5.6 mmHg, $P = 0.001$). A significant difference was also noted in the mean EtCO2 at 120 min of presentation between these groups of patients (24.3 ± 4.3 mmHg vs. 15 ± 8.5 mmHg, $P = 0.001$).

The proportion of patients in the study who survived till hospital discharge and those who did not have been classified by the type of shock and summarized in Table 2.

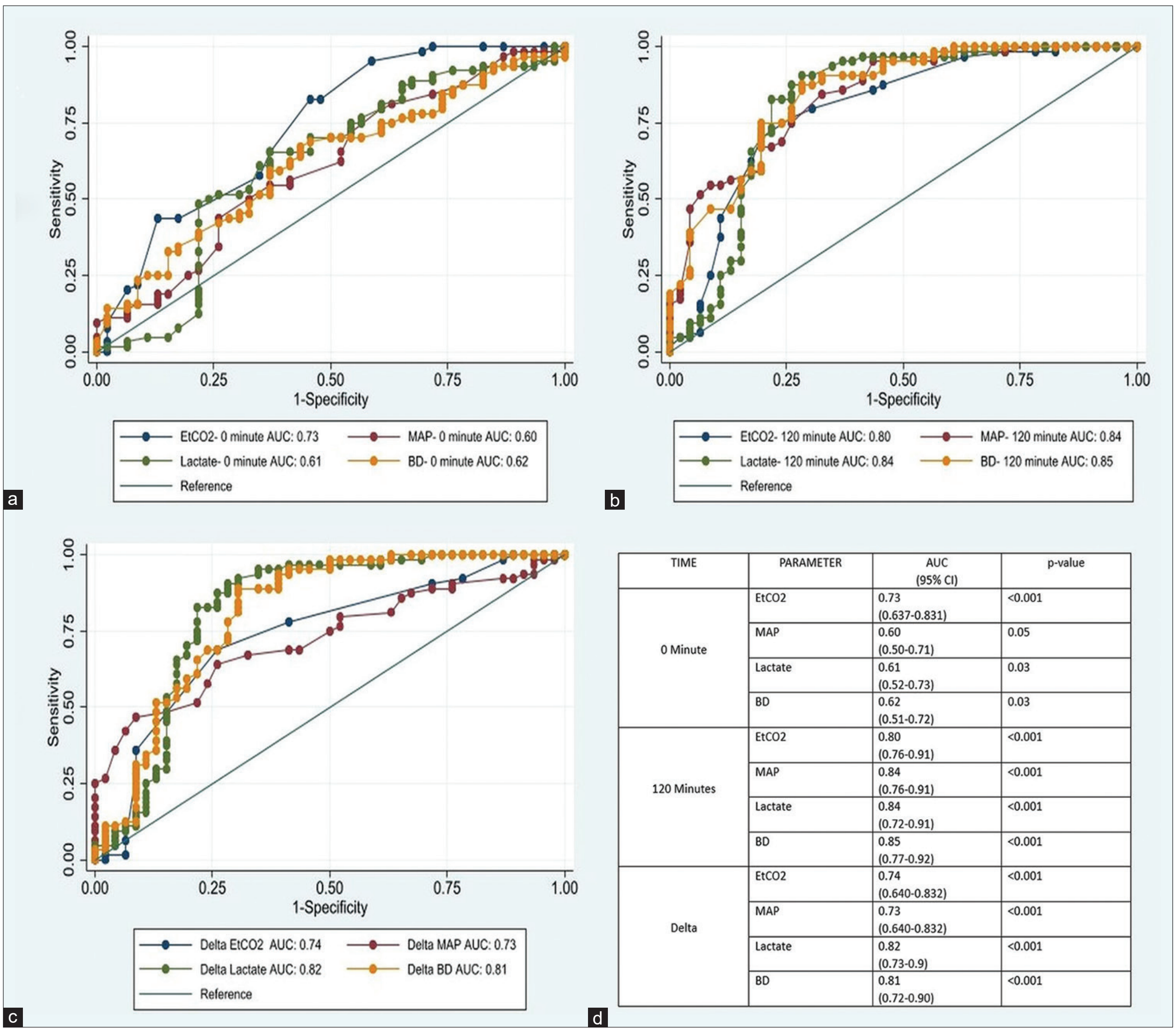
Out of 110 study participants, 39 (35.45%) patients underwent endotracheal intubation in the first 2 h of resuscitation. The mean EtCO2 at presentation did not differ significantly between the patients who required intubation and those who did not (20.2 ± 4.4 vs. 21.1 ± 5.2, $P = 0.328$). Twenty-six of the 39 intubated patients (66.6%) died during hospital stay, whereas 20 of the 71 nonintubated patients (28.17%) died in hospital.

The EtCO2 values measured by mainstream capnography and PaCO2 values on blood gas analysis showed statistically significant moderate correlations in nonintubated patients (Pearson's $r = 0.357$, $P < 0.001$) as well as in intubated patients (Pearson's $r = 0.525$, $P < 0.001$).

ROC analysis was done to assess the ability of EtCO2 to predict inhospital mortality of shock patients. EtCO2 at arrival was shown to predict mortality with an AUROC of 0.73 (95% confidence interval [CI]: 0.638–0.832, $P < 0.001$). EtCO2 at 120 min showed an AUROC of 0.80 (95% CI: $P < 0.001$) and the AUROC for delta EtCO2 was 0.74 (95% CI: 0.640, –0.832, $P < 0.001$). The differences between the predictive abilities of EtCO2 and the other measured parameters were not statistically significant at any of the abovementioned time points. The results are summarized in Figure 3.

An EtCO2 measurement of ≤ 23 mmHg at presentation was 87% sensitive (95% CI: 73%–95%) and 43% specific (95% CI: 31%–56%) in predicting inhospital mortality of patients presenting with circulatory shock in the ED. On regression analysis, an EtCO2 value of ≥ 23 mmHg was associated with an adjusted OR of 0.08 (95% CI: 0.02–0.3, $P < 0.001$) in predicting mortality, when adjusted for selected covariates (age, sex, MAP, lactate, and BD) [Supplementary Table 1].

EtCO2 values at presentation and 120 min showed statistically significant positive correlations with MAP and BD at the corresponding time points. Similarly, a significant negative correlation was demonstrated with lactate levels at the same time points. The results are summarized in Table 3. Delta EtCO2 also showed statistically significant positive correlations with delta MAP ($r = 0.245$, $P = 0.010$) and delta BD: ($r = 0.386$,



TIME	PARAMETER	AUC (95% CI)	p-value
0 Minute	EtCO2	0.73 (0.637-0.831)	<0.001
	MAP	0.60 (0.50-0.71)	0.05
	Lactate	0.61 (0.52-0.73)	0.03
	BD	0.62 (0.51-0.72)	0.03
120 Minutes	EtCO2	0.80 (0.76-0.91)	<0.001
	MAP	0.84 (0.76-0.91)	<0.001
	Lactate	0.84 (0.72-0.91)	<0.001
	BD	0.85 (0.77-0.92)	<0.001
Delta	EtCO2	0.74 (0.640-0.832)	<0.001
	MAP	0.73 (0.640-0.832)	<0.001
	Lactate	0.82 (0.73-0.9)	<0.001
	BD	0.81 (0.72-0.90)	<0.001

Figure 3: Receiver operating characteristic curve analysis for in-hospital mortality, (a) At 0-min, (b) At 120-min, (c) Change between 0 and 120 min (delta values), (d) Area under curve with *P* values of EtCO2, MAP, lactate, and base deficit and their delta values. AUC: Area under curve, EtCO2: End-tidal carbon dioxide, MAP: Mean arterial pressure, BD: Base deficit

Table 1: Demographic variables, mean vitals, and laboratory parameters at arrival to the emergency department

Parameter	*n* (%) or mean±SD
Age (years)	46.6±15.5 (15–82)
Gender	
Male	60 (54.6)
Female	50 (45.4)
Intubated	
Yes	39 (35.4)
No	71 (64.6)
Comorbidities	
Chronic liver disease	29 (26.4)
Malignancy	25 (22.7)
Heart disease	16 (14.5)
Diabetes mellitus	14 (12.7)
Hypertension	11 (10.0)
Others	15 (13.6)
Chief complaints	
Shortness of breath	33 (29.7)
Abdominal pain	27 (24.3)
Fever	25 (22.5)
Hematemesis	17 (15.3)
Loose stools	12 (10.8)
Altered mental status	8 (7.2)
Chest pain	5 (4.5)
Others	14 (12.6)
Type of shock	
Septic	45 (40.9)
Hypovolemic	33 (30)
Cardiogenic	19 (17.2)
Anaphylactic	3 (2.7)
Neurogenic	1 (0.9)
Mixed	9 (8.2)
Vital parameters at arrival, mean±SD (minimum–maximum)	
HR (beats/min)	114±24.5 (32–180)
SBP (mmHg)	78.3±13.3 (52–138)
DBP (mmHg)	49.2±10.4 (32–92)
MAP (mmHg)	60.3±10.9 (94–100)
RR (breaths/min)	24.1±3.9 (15–40)
SpO_2 (%)	95.3±4.5 (75–100)
Laboratory parameters at arrival, mean±SD (minimum–maximum)	
Lactate (mmol/L)	7.1±2.6 (2.2–16.2)
Base deficit (mEq/L)	−10.5±5.3 (−23.3–−3.2)
$PaCO_2$ (mmHg)	28.0±3.9 (11.1–39)
$EtCO_2$ at arrival (mmHg)	20.6±4.8 (9–38)

All continuous variables were distributed normally. HR: Heart rate, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, MAP: Mean arterial pressure, RR: Respiratory rate, SpO2: Oxygen saturation, SD: Standard deviation, $PaCO_2$: Partial pressure of carbon dioxide, $EtCO_2$: End-tidal carbon dioxide

$P < 0.001$), while correlating negatively with delta lactate ($r = -0.483$, $P < 0.001$).

Discussion

Our study showed that EtCO2 levels at presentation differed significantly between patients who survived to hospital discharge and those who did not. EtCO2 at presentation was found to have an AUROC of 0.735 ($P < 0.001$) in predicting inhospital mortality which was higher than lactate, BD, and MAP. An EtCO2 ≤ 23 mmHg was 87% sensitive and 43% specific in predicting inhospital mortality. EtCO2 ≥ 23 mmHg on arrival to ED independently predicted the risk of inhospital mortality with an adjusted OR of 0.08 (95% CI: 0.02–0.3; $P = 0.001$).

Carbon dioxide is one of the final products of cellular metabolism which is transported to the lungs through venous blood flow to the pulmonary alveoli and then exhaled out through the airways. Hence, EtCO2 measured by capnometry provides a dynamic assessment of the body's metabolic, circulatory, and respiratory status. E tCO2 monitoring has been used in cardiac arrest patients to guide the effectiveness of chest compression and to look for the return of spontaneous circulation (ROSC).[4,5] The principle is that EtCO2 is expected to be low/zero in a "no-flow state" such as cardiac arrest, due to absent circulation and alveolar ventilation, and should theoretically increase with chest compressions and ROSC as the cardiac output increases. These findings should remain the same theoretically when extrapolated to a "low-flow" state such as circulatory shock. However, whereas EtCO2 has been shown to predict inhospital mortality with variable sensitivity and specificity in traumatic hemorrhagic shock, this association in nontraumatic circulatory shock has been studied less extensively.

Our results showed parallels with previous studies in this area of research. Retrospective studies done in trauma patients identified EtCO2 cutoffs of 30 mmHg and 28 mmHg to be specific and sensitive in predicting mortality.[13,14] A prospective study done exclusively in nonintubated trauma patients identified that an EtCO2 <29.5 mmHg was associated with higher odds of mortality.[15] The accuracy of EtCO2 as a predictive tool was also found to be slightly higher in previous studies by Childress K *et al* and Hunter C L *et al* (AUROC of 0.84 and 0.76 respectively).[13,16] This difference in cutoff may be attributed to the recruitment of both intubated and nonintubated patients and the use of novel mainstream capnometer with oronasal sampling cannula for spontaneously breathing patients in our study, while the previous studies were predominantly confined to intubated patients. Most of the studies conducted in intubated patients with traumatic hemorrhagic shock have used sidestream capnography.[7,15,17,18] It also possibly mirrors the differences in resuscitative modalities in the resuscitation of traumatic shock and undifferentiated shock presenting to the emergency.[12,17,19] Multiple studies have demonstrated the superiority of EtCO2 to conventional markers such as SBP, lactate, MAP, BD, and shock index, in predicting mortality.[12,17,19] Whereas all these studies were

Table 2: Inhospital mortality and mean end-tidal carbon dioxide, mean arterial pressure and lactate values for each type of shock in the study population

Type of shock	Outcome		$EtCO_2$ (mean±SD)	MAP (mean±SD)	Lactate (mean±SD)
	Surviving, *n* (%)	Nonsurviving, *n* (%)			
Septic (*n*=45)	21 (46.7)	24 (53.3)	20±5	62±11	7.3±2.8
Hypovolemic (*n*=33)	20 (60.6)	13 (39.4)	19±4	59±11	6.9±2.5
Cardiogenic (*n*=19)	14 (73.7)	5 (26.3)	22±4	59±9	6.5±2.7
Anaphylactic (*n*=3)	3 (100)	0	24±1	62±11	6.3±1.7
Neurogenic (*n*=1)	0	1 (100)	24	48	11.2
Mixed (*n*=9)	6 (66.7)	3 (33.3)	19±4	55±5	7.4±1.8

$EtCO_2$: End-tidal carbon dioxide, SD: Standard deviation, MAP: Mean arterial pressure

Table 3: Correlation analysis of end-tidal carbon dioxide (delta end-tidal carbon dioxide*) with mean arterial pressure, lactate, and base deficit at 0 min, 120 min, and delta values

Time (min)	MAP		Lactate		Base deficit	
	Pearson's *r*	*P*	Pearson's *r*	*P*	Pearson's *r*	*P*
0	0.210	0.027	−0.211	0.020	0.259	0.006
120	0.438	0.000	−0.495	<0.001	0.539	<0.001
Delta values*	0.245	0.010	−0.483	<0.001	0.386	<0.001

*Delta values represent the change from 0 min to 120 min. MAP: Mean arterial pressure

conducted in traumatic patients, one was prospective in design and the other two were retrospective.[17] Our study, however, showed similar performances of all markers on ROC analysis, at multiple time points, as well as on comparison of delta values between time points. Individual parameters appeared to show a better predictive accuracy at 2 h of resuscitation, possibly reaffirming the effect of stabilization of these "vitals" as early as possible in the course of resuscitation, on mortality.

We also found that EtCO2 measurements at presentation as well as at 120 min of inhospital course showed statistically significant, albeit weak-to-moderate correlations with MAP, lactate, and BD values at the corresponding time points. The correlation between EtCO2 and these parameters at presentation has been demonstrated previously in a prospective study on 103 patients with shock, showing strong agreement with our results.[3] The inverse correlation between EtCO2 and lactate has been demonstrated significantly in multiple studies in the past. While Wiryana *et al*. demonstrated this relationship in 70 hemodynamically unstable patients aged 13–90 years without primary pulmonary disease ($r = -0.852$, $P = 0.001$), Hunter *et al*. showed this correlation in 201 patients with suspected sepsis ($r = -0.507$, $P < 0.001$).[20,21] This suggests that this correlation maintains its significance irrespective of etiology. This is important considering that our study had enrolled patients with multiple etiologies of shock. We also demonstrated a significant correlation between EtCO2 and lactate levels at multiple points of resuscitation. This showed parallels with the results of a cross-sectional study conducted on 84 patients with septic shock, demonstrating a significant inverse correlation between EtCO2 and lactate at presentation, at 3 h and 6 h from presentation.[18] However, a key difference from the above studies remains the lesser degree of correlation between the variables obtained in our study. A possible reason for this could be a higher proportion of decompensated chronic liver disease patients in our study population and a condition characterized by impaired lactate clearance. The evidence for correlations with MAP and BD are, however, less robust in literature. These results suggest that EtCO2 may be considered a reliable alternative for dynamic monitoring in patients with shock, especially in conditions where parameters such as lactate may not be reliable.

We also demonstrated that the change in EtCO2 in the first 2 h of resuscitation correlated moderately with changes in lactate, BD, and MAP over the same time period, another finding demonstrated in the study by Khajebashi *et al*.[18] This suggests that dynamic changes in EtCO2 with ongoing resuscitation may be a valuable adjunct in the monitoring of patients with nontraumatic circulatory shock in the ED.

A few disadvantages of EtCO2 measurement in the ED need to be kept in mind when interpreting the results of this study. While EtCO2 measurement in intubated patients may be considered a noninvasive, continuous, and reliable monitoring tool in critically ill patients, the same in nonintubated patients may be challenging as different sampling adapters are shown to have variable reliability. Further, the availability of such sampling adapters may be limited in many centers, especially in developing nations like India. Even in our study, the correlation between EtCO2 and PaCO2 was more robust in intubated patients than in nonintubated patients. Larger studies among nonintubated patients are required to determine the reliability and feasibility of capnography in such a patient population.

The technique of capnography-mainstream or sidestream could also potentially affect the reliability and accuracy of the results obtained. The mainstream technique is theoretically associated with more accurate values as they are not affected by circuit obstructions, drops in water pressure, or gaseous dispersion.[22,23] Isolated studies reflect positively on the accuracy of mainstream capnography and the correlation between measured PaCO2 and EtCO2.[23] However, comparisons of these techniques in terms of reliability and accuracy are limited in literature, casting doubts over the interpretation and application of our results across techniques. Importantly, our EtCO2 values showed statistically significant moderate correlations with PaCO2 values across intubated and nonintubated patients. This parallels the results of other studies comparing these values by mainstream capnography.[22-24]

The utility of EtCO2 for monitoring of circulatory insufficiency is also limited in patients with complex pulmonary pathologies, who have been excluded from our study. While conditions such as bronchial asthma and obstructive airway diseases could show increased EtCO2 values due to chronic airflow limitation, other conditions such as pulmonary embolism could show decreased values due to impaired alveolar perfusion. The unreliability of EtCO2 in this population is a significant drawback, as patients with complex pulmonary pathologies are frequently at increased risk for circulatory disturbances.

Limitations

Our study had a few limitations. This was a single-center study done with a small sample size. We used only mainstream capnography for the measurement of $EtCO_2$. Hence, the cutoffs generated may differ across other techniques. The reliability of EtCO2 measurement and their correlation with PaCO2 is dependent on the make and model of the capnometers available at respective institutions, hindering the generalizability of our results. Comparative analysis of the ability of EtCO2 in predicting mortality in intubated versus nonintubated patients was not performed, as the study was underpowered to do so. Further, subgroup analysis on the association between EtCO2 and inhospital mortality in different types of shock was not performed.

Conclusion

EtCO2 at presentation is a significant independent predictor of inhospital mortality in patients presenting to the ED in circulatory shock of nontraumatic etiology. EtCO2 may be considered for use as a monitoring modality for guiding resuscitation in this patient population. However, further studies with larger sample sizes are required to establish its routine application in the ED.

Acknowledgments

We extend our sincere gratitude towards Dr. Sanith K R , Dr. Vaishnavi T and Dr. Anujith Mahendran for their support and guidance throughout the conduct of this study.

Author contributions statement

AR: conceptualization, study design, data collection, and writing original articles. ME: supervision and study design. AS: interpretation of data and writing the original article. PA: supervision and revision of manuscript. NJ: supervision and revision of the manuscript. SB: supervision. MK: statistical analysis.

Conflicts of interest

There are no conflicts of interest.

Ethical approval

The study protocol was reviewed and approved by the Institute Ethics Committee of All India Institute of Medical Sciences (AIIMS), Ansari Nagar, New Delhi, with approval no: IECPG-554/23.09.2021.

Funding

None.

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Supplementary Table 1: Logistic regression analysis of individual variables with inhospital mortality

Parameter	Unadjusted odd's ratio (95% CI)	*P*
$EtCO_2$ (>23 mmHg)	0.19 (0.07–0.51)	0.01
Age	1.03 (1.0–1.06)	0.01
Sex (male)	2.4 (1.1–5.4)	0.02
MAP	0.95 (0.92–0.99)	0.04
Lactate	1.1 (1.0–1.3)	0.03
BD	0.92 (0.86–0.99)	0.04

$EtCO_2$: End-tidal carbon dioxide, MAP: Mean arterial pressure, CI: Confidence interval, BD: Base deficit