

End Tidal Carbon Dioxide (EtCO₂) Concentration, as a Predictor of Mortality and Morbidity among Patients Resuscitated in the Emergency Department

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Abstract

Traditionally, post resuscitation phase in the emergency department concentrates on the normalization of easily demonstrable vital signs such as heart rate, mean arterial pressure (MAP) and central venous pressure. The ultimate end point of all resuscitative measures is to achieve adequate tissue oxygenation and perfusion. However, it has been studied that these demonstrable vital signs are poor indicators of tissue level oxygenation and perfusion in the critically ill patients [1,2]. Capnography is measurement of the concentration of carbon dioxide (CO₂) at the end of each exhaled breath, commonly known as the end-tidal carbon dioxide (EtCO₂). It is a fast, non-invasive, and relatively inexpensive monitoring tool. EtCO₂ levels have been shown to be independently predictive of the patient's clinical status (9). In this study, we aim to record the EtCO₂ levels immediately after tracheal intubation and study if the subsequent trends in EtCO₂ levels can predict patient outcome in terms of morbidity (length of ICU stay, duration of mechanical ventilation, total duration of hospital stay) and mortality. *Methods and Material:* The study was conducted after approval from the institutional Scientific and Ethical committee. It was a prospective observational study; where in data was collected prospectively with no interventions on behalf of the investigator. For the purpose of statistical significance we have chosen to recruit eighty seven patients based on the results and statistical analysis from previous studies. The data collected was analyzed using specified statistical methods to derive association between the various study parameters under consideration. *Statistical analysis used:* Based on the results of a previous study (12), the mortality of these patients is (28/36) equal to 0.78, the specificity of EtCO₂ for mortality was observed to be 42.8% in the same subjects. Using these values, the sample size for detecting a minimum difference of 4% in specificity is 31, with power 80% and level of significance 5%. For the purpose of our study we choose to recruit a sample size of Eighty seven. *Conclusions:* Based on the results of previous studies and the results of our study it becomes imperative that EtCO₂ levels strongly predict survival in patients resuscitated in the emergency department, patients who fail to attain a higher EtCO₂ level (average mean 15 mm Hg at 0 min) post resuscitation have poorer outcomes in terms of survival.

Keywords: End-Tidal Carbon Dioxide (Etco₂); Intubation; Capnography; Morbidity.

Introduction

Capnography is measurement of the concentration of carbon dioxide (CO₂) at the end

of each exhaled breath, commonly known as the end-tidal carbon dioxide (EtCO₂). It is a fast, non-invasive, and relatively inexpensive monitoring tool. As long as the heart is beating and tissues are

perfused, CO₂ released from tissues is delivered continuously to the lungs for exhalation. Therefore, EtCO₂ levels have been studied as indicators of subtle changes in perfusion at the tissue level [3].

EtCO₂ levels have been shown to be independently predictive of the patient's clinical status [9]. Various studies conducted in this regard have shown consistent results depicting the role of EtCO₂ as an independent marker of patient survival, mortality and metabolic disturbances in critically ill patients [10,11]. To the best of our knowledge, none of the previous studies have compared EtCO₂ levels immediately following tracheal intubation in emergency situations. By means of this study, we aim to record the EtCO₂ levels immediately after tracheal intubation and study if the subsequent trends in EtCO₂ levels can predict patient outcome in terms of morbidity (length of ICU stay, duration of mechanical ventilation, total duration of hospital stay) and mortality.

Aims and objectives

Objective of the Study

1. To record EtCO₂ levels immediately after tracheal intubation.
2. To study the trends in EtCO₂ levels at various intervals in emergency department.
3. To study the association of initial post resuscitation EtCO₂ trends with morbidity and mortality amongst patients resuscitated in the emergency department.

Aim of the Study

1. To determine the prognostic significance of EtCO₂ levels as a predictor of mortality and morbidity among patients resuscitated in the emergency department.

Materials and Methods

The study was conducted after approval from the institutional Scientific and Ethical committee. It was a *prospective observational study*; where in data was collected prospectively with no interventions on behalf of the investigator. For the purpose of statistical significance we have chosen to recruit eighty seven patients based on the results and statistical analysis from previous studies.

The study was conducted in the Emergency department (ED) of Max Super Specialty Hospital,

Shalimar Bagh, which is a tertiary care referral hospital with an average of 9000 visits per annum. Recruitment of subjects was done on the basis of the inclusion and exclusion criteria.

The data collection was done prospectively from patient reports and case files with no intervention on behalf of the investigator. Patient safety and care was in no way compromised as the study is based on data which is yielded by routinely monitored parameters.

Baseline data including age, heart rate, blood pressure and oxygen saturation were recorded at the time of presentation to the ED. The decision of endotracheal intubation was taken by the treating clinician at the emergency department. Subjects undergoing endotracheal intubation in the emergency department were monitored for exhaled EtCO₂ concentrations at specified intervals. EtCO₂ levels were measured using a standard side stream capnometer attached to the Phillips GOLDWAY G 30 multichannel monitor.

For the purpose of standardization and achieving CO₂ level equilibrium between blood and alveoli, immediately after tracheal intubation four breaths of 10 ml/kg tidal volume at 12 frequency per minute were delivered to the patient with the help of ventilator. Thereafter, side stream capnography was established and EtCO₂ levels appearing first on the monitor were recorded. Further, the EtCO₂ levels were recorded at specified intervals 3, 8, 15, 30 min and one hourly up to the duration of patient's stay in the emergency department.

The study subjects were followed prospectively during the duration of hospital stay. Patient's parameters like total length of hospital stay, duration of mechanical ventilation, length of intensive care unit stay and final outcome in terms of patient survival and associated co morbidities were recorded.

The data collected was analyzed using specified statistical methods to derive association between the various study parameters under consideration.

Inclusion Criteria

- Age > 18yrs.
- Both genders.
- Patients requiring endotracheal intubation in the emergency department.

Exclusion Criteria

- Patients with chronic respiratory disease.

- Pregnant females.
- Trauma patients.
- Failed intubations.
- Unwitnessed cardiac arrest.
- Patients intubated before reaching the emergency room.
- Patient who are transferred to another health care facility.
- International patients.

1. Mortality of these patients would not be known.
2. The length of hospital stay is highly skewed.

Using Regression model with length of hospital stay and EtCO₂ and other factors which are influencing length of hospital stay as predictors. For mortality, logistic regression with EtCO₂ and any other factor as predictor.

Results

During the study period a total of eighty seven patients were enrolled on a sequential basis. The summarized data collected as per the specified data collection sheets was subjected to statistical analysis using Tables and Graphs. Data was normally distributed as tested using the Shaperio-Wilk W test (p-value was less than 0.05).

Level of statistical significance was set at p-value less than 0.05.

Demographic details:

Statistical analysis used

Based on the results of a previous study [12], the mortality of these patients is (28/36) equal to 0.78, the specificity of EtCO₂ for mortality was observed to be 42.8% in the same subjects. Using these values, the sample size for detecting a minimum difference of 4% in specificity is 31, with power 80% and level of significance 5%. For the purpose of our study we choose to recruit a sample size of Eighty seven.

The method of survival analysis will be used to study the length of hospital stay (morbidity) because:

Table 1: Showing the Distribution of study population according to age group.

	Survived		Expired	
	N	%	n	%
Less than and equal to 50 years	36	55.4	13	59.1
More than 50 years	29	44.6	9	40.9
Total	65	100	22	100

Table 2: Distribution of study population based on final outcome

Study Population	Survived		Expired		Total	
	n	%	n	%	n	%
	65	74.7	22	25.3	87	100

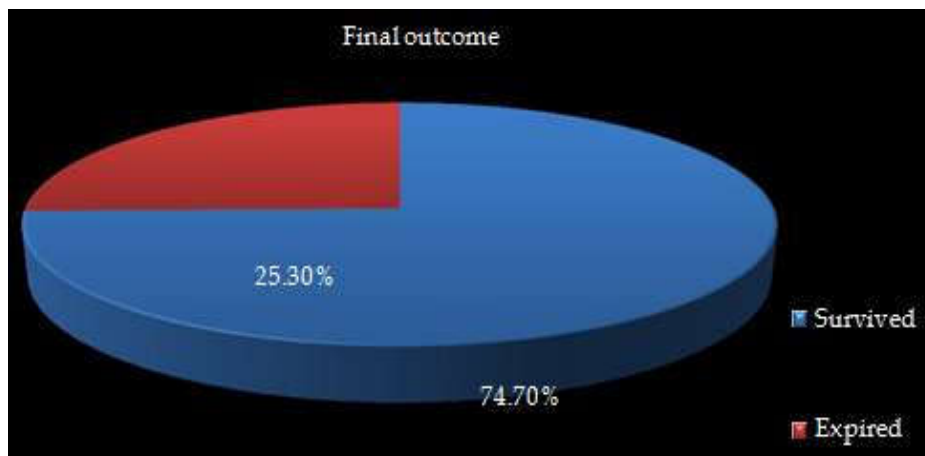


Fig. 1: Distribution of study population based on final outcome

Table 3: Mean and standard deviation of EtCO₂ (End Tidal carbon dioxide levels) levels at different intervals of time after tracheal

	Survived		Expired	
	MEAN	SD	MEAN	SD
Immediately, at 0 min	34.9	8.08	15.0	6.17
After 3 min	35.06	6.65	14.36	7.32
After 8 min	36.5	5.32	15.0	3.08
After 15 min	35.7	6.49	12.8	4.51
After 30 min	34.8	5.98	15.4	8.57
After 1 hour	38.67	6.08	14.8	7.2

Table 4: Mean and standard deviation of EtCO₂ (End Tidal carbon dioxide levels) levels for other factors

	Survived		Expired	
	MEAN	SD	MEAN	SD
Heart rate (beats/min)	114.18	13.80	117.72	10.54
<i>Blood pressure</i>				
systolic	108.46	25.81	113.18	26.25
diastolic	68.61	15.89	72.27	14.11
Respiratory rate (cycles/min)	23.01	1.94	22.18	2.59
(SpO ₂) pulse Oximetry	88.72	3.59	86.04	4.20
Length of ICU stay (days)	5.29	1.72	2.90	2.63
Duration of mechanical Ventilation (days)	2.95	1.30	2.90	2.63

Table 5: Diagnostic performance indicators on best intersection point of 0,3 min, 8 min, 15 min, 30 min and 1 hour measurements

Indicators	No. of patients	Sensitivity	Specificity	PPV	NPV	AUROC	P value
Immediately, at 0 min	87	96.9%	72.7%	91.3%	88.9%	0.956	0.00
After 3 min	87	96.9%	86.4%	95.5%	90.5%	0.945	0.00
After 8 min	87	96.9%	81.8%	94.0%	90.0%	0.985	0.00
After 15 min	87	98.5%	90.9%	97.0%	95.2%	0.993	0.00
After 30 min	87	96.9%	81.8%	94.0%	90.0%	0.915	0.00
After 1 hour	87	96.9%	81.8%	94.0%	90.0%	0.971	0.00

TP: True Positive, FN: False Negative, TN: True Negative, FP: False Positive, PEV: Positive Predicted Value, NEV: Negative Predicted Value.

Discussion

As EtCO₂ has been shown to be a predictor of ROSC in previous studies, with the potential of being a non invasive tool for monitoring patient outcomes in the emergency department.

From the results of previous studies we find that EtCO₂ levels >10 mm Hg and persisting above the mean with <25 % fall from baseline are a predictor of ROSC in out of hospital cardiac arrest patients.

Most of the studies with EtCO₂ have tried to co relate EtCO₂ levels with ROSC or survival in patients with cardiac arrest requiring CPR.

In our study we have focused on a different subset of patients who are put on ventilatory support as a part of resuscitation in the emergency department,

but not in need of CPR. By resuscitation we mean all measures excluding CPR, thus limiting our subset to patients who are in need of supportive therapy like iv fluids, vasopressors, airway protection and other therapeutic modalities but are maintaining an intact airway.

Our study included 87 patients on a sequential basis, patients intubated in the emergency department for various indications were monitored for EtCO₂ levels post intubation for specified intervals of time.

The trends in EtCO₂ concentration were recorded and using statistical designs the data was analyzed for significant co-relation with various other variables, mortality and morbidity being the principal outcomes.

The EtCO₂ levels recorded at various intervals showed a mean of 34.9 immediately post resuscitation in the survivors and a mean of 38.67 at one hour. Among the non survivors the mean stood at 15.0 immediately post resuscitation and 14.8 after one hour post intubation.

Using logistic regression to ascertain the effects of initial post resuscitation EtCO₂ levels on the survival of patients, the P value was <0.0005 which is statistically quite significant with the odds of survival 84 times greater with increasing EtCO₂ levels at zero min that is immediately post resuscitation.

For morbidity in terms of length of hospital stay, duration of mechanical ventilation, co morbidities the logistic regression model was not statistically significant.

Of a total of 87 patients enrolled in the study 22 patients expired and were allotted to the mortality group, the remaining 65 patients survived and were followed for other morbidity data.

Among the non survivors considering the in hospital morbidities, the total length of ICU stay was 2.9 days on an average with a standard deviation of 2.63, the total duration of mechanical ventilation was 2.9 days with a standard deviation of 2.63.

Analysis of EtCO₂ levels post resuscitation reveals that all the survivors had EtCO₂ levels at an average mean above 30 with minimal standard deviation of 5.32, on the contrary all the non survivors had an average EtCO₂ level below a mean of 15.0 with a minimal standard deviation of 3.08.

As already discussed that EtCO₂ levels predicted mortality with significance, the morbidity data could not be predicted significantly because the non survivor group had a terminal event i.e death with a much shorter duration of hospital stay and data for comparison of morbidity statistics was limited due to non survival of these patients.

Conclusion

Based on the results of previous studies and the results of our study it becomes imperative that EtCO₂ levels strongly predict survival in patients resuscitated in the emergency department, patients who fail to attain a higher EtCO₂ level (average mean 15 mm Hg at 0 min) post resuscitation have poorer outcomes in terms of survival.

Although our model could not get a statistical co relation for morbidity prediction, because the data for morbidity co relation was sparse as death was

the terminal event in the non survivor group, with limited duration of hospital stay. The morbidity parameters currently taken into consideration were dependant upon patient survival, and further studies are warranted in this regard to derive the correlation of EtCO₂ levels with morbidity in such patients.

EtCO₂ levels post resuscitation are a strong non invasive tool for predicting survival in the emergency department helping guide therapy and initiate aggressive measures for improving patient outcomes, and should be incorporated in routine monitoring of patients post resuscitation in the Emergency room.

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