TITLE: USE OF COLORIMETRIC END-TIDAL CARBON DIOXIDE MONITORING TO PROGNOSTICATE IMMEDIATE RESUSCITATION FROM CARDIAC ARREST

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INTRODUCTION: Inability to resuscitate a patient from cardiac arrest has been associated with an end-tidal carbon dioxide ($ETCO_2$) partial pressure of less than 10 torr recorded by an infrared capnometer.[1] Although this equipment is present in many operating rooms and critical care units, it is expensive and not readily available in other patient care areas. Recently, a disposable, noninvasive and inexpensive colorimetric $ETCO_2$ detector (Fenem, New York, N.Y.) has been made available. The purpose of this study was to determine if the data obtained by this new device can be used as a prognostic indicator of successful resuscitation from cardiac arrest in patients.
METHODS: The study protocol was approved by the University of Miami Medical Sciences Subcommittee For the Protection of Human Subjects. From June 1989 to January 1990 we prospectively studied all patients for whom CPR was given, emergency intubation was required and an $ETCO_2$ detector was used in Jackson Memorial Medical Center. A cardiac arrest team directed by a senior medical resident trained in the American Heart Association's advanced cardiac life support standards and guidelines for CPR[2] responded to all cardiac arrest calls. A respiratory therapist instructed in the use of the $ETCO_2$ detector was responsible for attaching this device immediately following intubation and recording the color range on full expiration. The $ETCO_2$ detector incorporates a color scale that corresponds to three ranges of CO_2: .2 to <3.8, 3.8 to <15.2 and 15.2 to 38 torr. The color range of the indicator was recorded during CPR after the endotracheal tube was in the tracheal position (as corroborated by auscultation of breath sounds or repeat laryngoscopy) and perfusion optimized ($ETCO_2$ DURING). The $ETCO_2$ was also recorded at the moment the team leader directed CPR efforts to cease either because of their futility or successful resuscitation ($ETCO_2$ FINAL). The patients were considered resuscitated if they were alive when the physician in charge of the arrest approved the departure of the cardiac arrest team. Survival and hospital discharge status of the resuscitated patients was determined by chart review. Patients were divided into two groups: those in which the $ETCO_2$ range was <15.2 torr and those in which the $ETCO_2$ range was ≥15.2 torr. The number of patients successfully resuscitated (R) and not successfully resuscitated (NR) was compared in both groups by using a two tailed Fisher's exact test.
RESULTS: A total of 57 patients who suffered a cardiac arrest were studied with colorimetric $ETCO_2$ monitoring. Patients with an $ETCO_2$ ≥15.2 torr measured either during or at the end of resuscitation had a higher incidence of successful resuscitation (Table). However, only one of the resuscitated patients lived to discharge from the hospital.

	$ETCO_2$ DURING (n=57)		$ETCO_2$ FINAL (n=57)	
Color Range	R	NR	R	NR
<15.2 torr	0	6	0	10
≥15.2 torr	26	25	26	21
	p= .04		p= .002	

DISCUSSION: If the $ETCO_2$ range detected by this device during CPR remains low (<15.2 torr), despite correct endotracheal intubation and optimization of perfusion, successful resuscitation is unlikely. This information may help the physician decide when to stop the resuscitation efforts. If the $ETCO_2$ range is high (≥15.2 torr), the resuscitation efforts are probably adequate and successful immediate resuscitation is more likely. If the $ETCO_2$ is low and correct endotracheal intubation is verified, efforts should immediately be directed at improving all components of basic and advanced cardiac life support. An increase in $ETCO_2$ provides an immediate bedside validation of the efficacy of the resuscitative effort. This is important as the likelihood of successful restoration of circulation is directly related to coronary perfusion which depends upon CPR-generated cardiac output and inversely related to the duration of arrest and CPR. This study shows that the data obtained from colorimetric $ETCO_2$ monitoring is a useful prognostic indicator of successful immediate resuscitation from cardiac arrest in patients.
REFERENCES: 1. JAMA 262:1347, 1989. 2. JAMA 255: 2905, 1986.

TITLE: CLINICAL UTILITY OF A COLORIMETRIC END-TIDAL CARBON DIOXIDE DETECTOR IN EMERGENCY INTUBATION.

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INTRODUCTION: The purpose of this study was to determine the clinical utility of a colorimetric end-tidal carbon dioxide detector (Fenem, New York, N.Y.) in patients requiring emergency intubation for respiratory distress or cardiopulmonary arrest.
METHODS: The study protocol was approved by the University of Miami Medical Sciences Subcommittee For the Protection of Human Subjects. From June 1989 to January 1990 we prospectively studied all patients in Jackson Memorial Medical Center for whom the CPR team was called and/or emergency intubation was required and an end-tidal carbon dioxide ($ETCO_2$) detector was used. A cardiac arrest team directed by a senior medical resident trained in the American Heart Association's advanced cardiac life support standards and guidelines for CPR[1] responded to all cardiac arrest calls. A respiratory therapist instructed in the use of the $ETCO_2$ detector was responsible for attaching this device immediately following intubation and recorded the color range of the indicator on full expiration after at least 6 breaths. The $ETCO_2$ detector incorporates a color scale that corresponds to three ranges of CO_2: .2 to <3.8, 3.8 to <15.2 and 15.2 to 38 torr. When the $ETCO_2$ range detected by this device was <15.2 torr, the physician in charge of the resuscitation or intubation was notified: "the endotracheal tube may be misplaced or perfusion may be inadequate." The patient's management was determined by the physician in charge and not by this study protocol. Management changes (attempts to increase perfusion or replace endotracheal tube) by the team leader after the above information was provided and concomitant changes in the color range were recorded. The patients were divided into two groups those who required intubation for respiratory distress or respiratory arrest (pulse present), and those who had a cardiopulmonary arrest. A false-negative (FN) result was defined as an $ETCO_2$ range <15.2 torr when correct endotracheal tube (ETT) placement was confirmed by auscultation of breath sounds or repeat laryngoscopy. A false-positive (FP) result was defined as an $ETCO_2$ range ≥15.2 torr when esophageal tube placement was detected by auscultation or repeat laryngoscopy. The positive and negative predictive values for correct intubation were calculated based on the $ETCO_2$ color range immediately after intubation and after attempts to increase perfusion. The number of cases in which the information provided by the detector modified management was determined from the data collection forms.
RESULTS: The colorimetric $ETCO_2$ detector was highly specific for correct endotracheal intubation in all patients. It was also highly sensitive for correct endotracheal intubation in patients intubated for respiratory distress but not in patients with cardiopulmonary arrest and low perfusion. The sensitivity improved when the $ETCO_2$ color range considered was the one obtained after attempts to increase perfusion (Table).

Group	FN	FP	TN	TP	Sens.	Specif.	PPV	NPV	Rx
Resp. distress or arrest (n=53)	1 [0]	0 [0]	5 [5]	47 [48]	0.98 [1]	1 [1]	1 [1]	0.83 [1]	1
Cardiopulm. arrest (n=57)	20 [6]	0 [0]	5 [5]	32 [46]	0.62 [0.88]	1 [1]	1 [1]	0.20 [0.45]	19

Sens.= sensitivity (TP/TP+FN); Specif.= specificity(TN/TN+FP); PPV= positive predictive value (TP/TP+FP); NPV= negative predictive value (TN/TN+FN); Rx= therapy change; [ ]= after increased perfusion attempts.

DISCUSSION: After emergency intubation for respiratory distress or cardiopulmonary arrest an $ETCO_2$ range ≥15.2 torr recorded by this device indicates correct ETT placement. An $ETCO_2$ range of <15.2 torr indicates ETT misplacement or, in patients undergoing CPR, low perfusion. Clinicians should immediately verify the ETT position by other means and immediately attempt to increase perfusion. This study indicates that the colorimetric $ETCO_2$ detector is reliable and provides reassurance of correct ETT placement in patients requiring emergency intubation for respiratory distress. This tool also helps identify patients with low perfusion during CPR and, if efforts directed at improving perfusion are successful, may improve cardiac resuscitation outcome.
REFERENCES: 1. JAMA 255: 2905, 1986.

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