Role of End-Tidal CO2 Monitoring in Patients Intubated and Resuscitated in the Emergency Department

Abstract: Objective: We examined the reliability of end-tidal CO2 (ETCO2) level in predicting mortality after endotracheal intubation in emergency situations.

Methods: In this prospective study, the reliability of ETCO2 monitoring in the emergency setting as a useful predictor of outcome was investigated in 36 adult patients with pending cardiopulmonary collapse. The cardiopulmonary resuscitation (CPR) procedure was performed as usual and the cardiac rhythm, arterial O2 saturation, non-invasive blood pressure and ETCO2 levels were continuously monitored in all the patients.

Results: Patients with an ETCO2 concentration below 0.5% had significantly lower rates of survival. The sensitivity and specificity values of end-tidal CO2 levels equal to or greater than 0.5% in predicting survival were 100% and 42.8%, respectively. None of the 8 patients with levels below 0.5% survived. An end-tidal CO2 concentration level of 0.5% served to discriminate between survivors and non-survivors.

Conclusions: These results suggest that the initial ETCO2 concentration can be an important predictor of outcome, especially with regard to mortality in patients undergoing endotracheal intubation.

Key Words: End-Tidal CO2, Monitoring, Mortality, Cardiopulmonary Resuscitation

Introduction

In recent years the use of capnometry has been increasing in intensive care and emergency departments (ED). Its primary indications are the detection of adverse airway events like endotracheal tube dislodgement or occlusion, and it is used as an adjunct in the decision-making process for endotracheal intubation (1-3). End-tidal CO2 levels have a high correlation with cardiac output, cerebral perfusion pressure and return of spontaneous circulation (ROSC) rates in animals (4-6) and humans (7). Ornato et al. (8) reported that an ETCO2 concentration level of 0.5% can serve as a reliable cutoff point between survivors and non-survivors. The aim of the present study was to test the accuracy of this level in an emergency care setting.

End-tidal CO2 can herald a number of adverse events that lead to inadequate perfusion in the critical care of patients, for example, shock, embolism, acute cardiac failure, and respiratory distress syndrome, and facilitates timely management of these states. Chronic pulmonary diseases and acute problems causing decreased lung perfusion, e.g., pulmonary embolism, hypotension and decreased cardiac output, lead to an increase in alveolar dead space, dilute expired CO2 and eventually reduce the ETCO2 concentration.

This prospective, observational study hypothesizes that end-tidal CO2 levels measured at the moment of intubation in a patient with impending cardiopulmonary collapse can reliably predict 15-day mortality in patients in the ED.

Materials and Method

After approval from the ethics committee was obtained, this study was conducted in the university ED between 15 October 1997 and 1 March 1998. The inclusion criteria were the decision to intubate due to impending cardiopulmonary arrest or "collapse" in the ED and the performing of cardiopulmonary resuscitation (CPR). Excluded from the study were patients with signs of trauma, those intubated before reaching the ED, and those showing no vital functions on first examination.

The study was based on 36 consecutive adult patients who met the criteria above and underwent intubation and...
CPR. Endotracheal intubation and CPR were carried out as indicated in advanced cardiac life support (ACLS) protocols (9). The mean age (±SD) of the 36 patients was 61.1±13.6 years and the male:female ratio was 25:11. Forty-four percent had a history of cardiac disease while 33% had a history of central nervous system disease and 36% suffered from pulmonary diseases.

IV lines and O\textsubscript{2} (10 l/min) were started for all the study patients in addition to electrocardiographic monitoring. The patients were intubated via the orotracheal route when appropriate. The indications for intubation in this study were respiratory distress, loss of consciousness (Glasgow Coma Scale: less than eight), and profound and refractory hypotension. The patients were sedated and paralyzed in the emergency setting using short-acting benzodiazepine (midazolam) and short-acting barbiturate (thiopenthal), opiate derivatives, succinylcholine and various combinations of these drugs.

The CPR procedure was performed according to the ACLS protocols published by the American Heart Association, which consists of ventilation, chest compressions, IV drugs whenever indicated and electrical direct-current cardioversion in the treatment of ventricular tachycardia and fibrillation. The cardiac rhythm, arterial O\textsubscript{2} saturation, non-invasive blood pressure and ETCO\textsubscript{2} levels were continuously monitored in all the patients throughout the treatment via the same device (Athena NT- Expired CO\textsubscript{2} Plug-In, White; Serial Number: 10994596; S&W Medico Teknik A/S, Herstedvang 8, 2620 Albertslund, Denmark. Ordering number: 65040-8 9270W GB). Two types of ETCO\textsubscript{2} monitoring device are commonly used and both techniques are based on the principle of the absorption of infrared light by CO\textsubscript{2}. Semi-quantitative sidestream capnography, which was used in our study, aspirates the gas mixture in the respiratory circuit and compares the absorption of infrared light in the sample gas with the absorption in the other chamber, which does not contain CO\textsubscript{2}. A T-shaped tube is attached to the outer part of the tube and conveys the gas to the circuit. It gives a branch of 180 cm to the measuring chamber of the monitor with which to identify the concentration of ETCO\textsubscript{2} in the aspirated sample.

Verification of the tracheal intubation was performed by bilateral auscultation of lung fields, and by examining post-intubation chest x-rays, arterial blood gases and clinical signs. The patients were ventilated via a bag-valve-mask device before being connected to mechanical ventilation. These patients were administered a longer-acting muscle-relaxant (vecuronium, 0.1 mg/kg) and sedatives (diazepam, 0.1 mg/kg). The mechanical ventilation was adjusted as needed and a tidal volume was applied at 6-8 ml/kg. This was altered according to the patient’s condition.

The ETCO\textsubscript{2} levels concurrent with intubation and at 1st, 10, and 20 minutes were recorded on study forms along with all the other monitored variables. The follow-up of all the patients lasted 15 days. The mean ETCO\textsubscript{2} level each patient was defined as the average of the values recorded at 1, 10 and 20 minutes.

Statistical calculations were performed using ‘SPSS for Windows 6.0’. We compared the survival of patients with ETCO\textsubscript{2} levels below 0.5% and that of patients with ETCO\textsubscript{2} levels above 0.5% using Fisher’s exact test.

The difference between the groups with ETCO\textsubscript{2} levels above and below 0.5% with respect to predicting 15-day mortality was examined via analysis of $\chi^2$Yates.

**Results**

The mean ETCO\textsubscript{2} levels (±SD) of the 36 patients in the study at time zero (the moment when intubation has occurred) and 1, 10 and 20 minutes after intubation were 1.1±1.0%, 0.6±0.4%, 0.5±0.6% and 0.6±0.9%, respectively. Only the level at time zero was significantly higher than the others ($p<0.05$). In 6 patients (16.6%) the initial intubation attempt was unsuccessful or ‘esophageal’. This was detected without significant delay and corrected at the second attempt.

The mean blood pressure value (±SD) of the patients was 98±13.5 mmHg at time zero. Nine patients had mean blood pressure levels lower than 90 mmHg and all of these patients had mean ETCO\textsubscript{2} levels lower than 0.5%. Only 8 of the 27 cases with mean blood pressure level higher than 90 mmHg had mean ETCO\textsubscript{2} levels lower than 0.5%.

The pulse rates ranged from 45 to 134 beats per minute. There was no significant correlation between pulse rate and ETCO\textsubscript{2} level or survival of the patients.

The ETCO\textsubscript{2} concentration values of 24 patients (66.6%) at time zero were above or equal to 0.5%, and the values of the 12 patients (33.3%) were below the cutoff point.

All of the 12 patients whose initial ETCO\textsubscript{2} levels were below 0.5% died after CPR while 16 (66.6%) of the 24
Patients whose initial ETCO₂ concentration values were above or equal to 0.5% died and the other 8 (33.3%) survived for at least 15 days. The sensitivity and specificity values of initial the ETCO₂ levels equal to or above 0.5% in terms of predicting survival were found to be 100% and 42.8%, respectively (Table 1).

Patients with ETCO₂ levels below 0.5% lived for a significantly shorter time than the others (Fisher’s exact test: one-tailed p=0.0243).

The mean ETCO₂ concentration was below 0.5 in 17 patients (47.2%) and equal to or above 0.5 in 19 (52.8%). All the patients with mean ETCO₂ levels below 0.5 died. Eleven patients (57.9%) with mean ETCO₂ levels equal to or above 0.5% survived. In other words, all the survivors were those with mean ETCO₂ levels equal to or above 0.5% (Table 2). There was a statistically significant difference between the subgroups in terms of 15-day survival (Mann-Whitney U test: U=44.0; two-tailed p=0.0028).

Three of the 11 female patients (27%) and 5 of the 25 male patients (20%) survived to the 15th day. The difference between the sexes was not found to be statistically significant in terms of 15-day survival (Fisher’s exact test: two-tailed p=0.6781).

The mean age (±SD) of the 8 survivors was 62.7±14.0 whereas the mean age of the 28 non-survivors was 58.8±12.3. The difference between the two groups in terms of age was not statistically significant (Mann-Whitney U test: U=100.0; two-tailed p=0.647).

### Table 1. Initial ETCO₂ concentration levels and 15-day survival rates.

<table>
<thead>
<tr>
<th>ETCO₂ concentration</th>
<th>Patients who survived</th>
<th>Patients who died</th>
<th>Number and % of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETCO₂&gt;0.5% line %</td>
<td>33.3</td>
<td>66.7</td>
<td>24 pts</td>
</tr>
<tr>
<td>column %</td>
<td>100.0</td>
<td>57.1</td>
<td>66.7</td>
</tr>
<tr>
<td>ETCO₂&lt; 0.5% line %</td>
<td>0.0</td>
<td>100.0</td>
<td>12 pts</td>
</tr>
<tr>
<td>column %</td>
<td>0.0</td>
<td>42.8</td>
<td>33.3</td>
</tr>
<tr>
<td>Total</td>
<td>8 pts</td>
<td>16 pts</td>
<td>24 pts</td>
</tr>
<tr>
<td>Total %</td>
<td>22.2</td>
<td>77.7</td>
<td>100.0</td>
</tr>
</tbody>
</table>

### Table 2. Mean ETCO₂ concentration levels and 15-day survival rates.

<table>
<thead>
<tr>
<th>ETCO₂ concentration</th>
<th>Patients who survived</th>
<th>Patients who died</th>
<th>Number and % of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETCO₂&gt;0.5% line %</td>
<td>42.1</td>
<td>57.9</td>
<td>19 pts</td>
</tr>
<tr>
<td>column %</td>
<td>100.0</td>
<td>39.3</td>
<td>52.8</td>
</tr>
<tr>
<td>ETCO₂&lt; 0.5% line %</td>
<td>0.0</td>
<td>100.0</td>
<td>17 pts</td>
</tr>
<tr>
<td>column %</td>
<td>0.0</td>
<td>60.7</td>
<td>47.2</td>
</tr>
<tr>
<td>Total</td>
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<td>11 pts</td>
<td>19 pts</td>
</tr>
<tr>
<td>Total %</td>
<td>22.2</td>
<td>77.7</td>
<td>100.0</td>
</tr>
</tbody>
</table>
resuscitative efforts could be guided by this variable. Likewise, Steedman (14) examined the values of cardiac arrest victims at 2 and 8 minutes and reported that an upsurge in ETCO2 levels generally heralded ROSC.

In our study, the sensitivity and specificity of an initial ETCO2 level equal to or greater than 0.5% in predicting 15-day survival were found to be 100% and 42.8%, respectively. The sensitivity level in our study was relatively high compared to other findings in the literature. This cutoff level should be tested by broader well-designed studies.

The assumption that a critical ETCO2 concentration level is highly sensitive in terms of predicting mortality in CPR patients implies that all the survivors had ETCO2 values equal to or greater than the critical value. We also know that in recent years the health sector has been looking to cut health care costs, of which unsuccessful CPR is a contributing factor. From this point of view, resuscitative measures for cardiac arrest patients within certain predefined clinical circumstances could be reassessed.

The survival times of patients with mean ETCO2 concentration levels below 0.5% were significantly shorter than those of the other patients. This suggests that morbidity factors like hypoperfusion and shock exert their effects on the organism throughout the CPR process.

Broader, well-designed studies will help to establish the exact role of end-tidal CO2 monitoring in patients undergoing CPR in the emergency setting.

ETCO2 levels can be a useful guide in determining the survivability of emergency department patients undergoing endotracheal intubation and CPR due to non-traumatic cardiopulmonary deterioration and impending circulatory arrest. The results of this study suggest that an initial ETCO2 concentration higher than a certain cutoff point is an important predictor of mortality in the critical care setting. More frequent use of capnography in the emergency setting may facilitate decision-making in the management of critical patients.

References