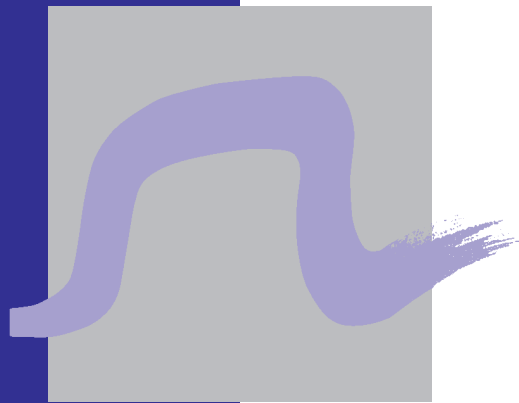


Capnography in Emergency Medicine





INTRODUCTION

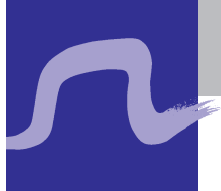
This publication is intended to illustrate the clinical utility of capnography in Emergency Medicine. The cases presented are based on actual situations in which capnography can alert healthcare professionals to conditions which require immediate attention.

For additional information or references, please contact your Respironics Area Sales Representative or call Respironics at 1-800-345-6443 or 724-387-4000.





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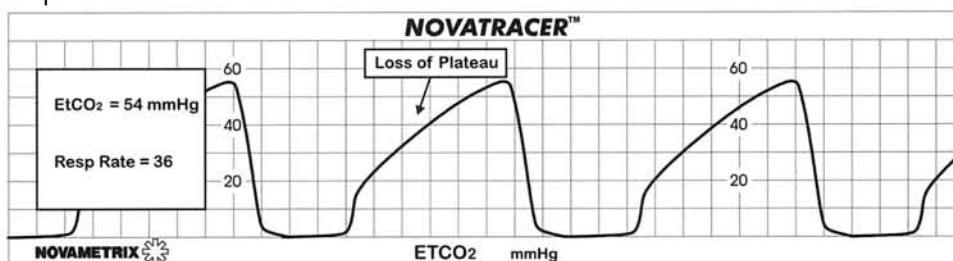


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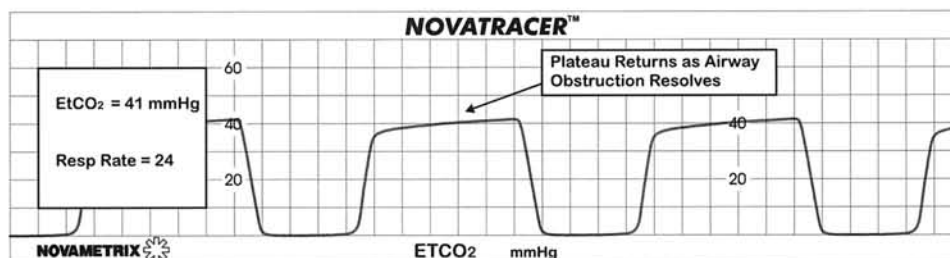
Child with an acute asthma attack admitted to the Emergency Department

Profile:

A 6 year old male with a history of asthma is admitted to the Emergency Department with audible expiratory wheezing. Patient has vital signs of Heart Rate 134, BP 114/46 and Respiratory Rate 36. Patient is placed on a capnograph/pulse oximeter via a nasal CO₂ cannula, with results of SpO₂ 91%, ET_{CO}₂ 54 mmHg. The patient's capnograph tracing demonstrates an abnormal waveform which is consistent with significant bronchospasm.



Patient is put on low flow oxygen and administered an inhaled bronchodilator treatment with an Albuterol Solution (0.25 ml Albuterol in 2 cc N/Saline). Significant improvement was evident in the patient's capnograph tracing, breath sounds and oxygenation status.



Discussion:

Use of the CO₂SMO® capnograph/pulse oximeter in the assessment of bronchospasm provided an objective measurement of the severity of the airway obstruction. Capnography has the added benefit of being non-invasive, patient effort independent and measurements can be made during normal tidal breathing.

"... the analysis of the capnogram's shape is a quantitative method for evaluating the severity of bronchospasm. This ability, added to specific advantages (non-invasiveness, effort-independency, measurements during tidal breathing) open new fields of application to capnography, such as measurement of bronchospasm in children . . ."

Smith T.C., Proops D.W., Pearman K., Hutton P., "Nasal capnography in children: automated analysis provides a measure of obstruction during sleep," *Clinical Otolaryngol*, 18:1: 69-71, February 1993.

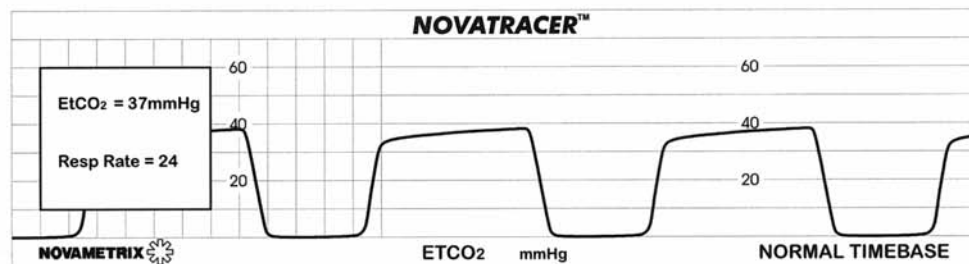


Case Report:

Pediatric patient complaining of abdominal pain following a bicycle accident

Profile:

An 11 year old girl is admitted to the Emergency Department with upper abdominal pain following a fall from her bicycle. Patient has vital signs of Heart Rate 112, BP 113/54, Respiratory Rate 24. Patient is placed on a capnograph/pulse oximeter via a nasal CO₂ cannula, with results of SpO₂ 97% and ETCO₂ 37 mmHg.



Discussion:

The use of the CO₂SMO[®] capnograph/pulse oximeter provided a quick and useful assessment of the patient's oxygenation and ventilation status. The normal end-tidal CO₂ and oxygen saturation values, in conjunction with a normal capnograph tracing, can assist in a non-invasive assessment of the patient's respiratory status without the need for costly and painful invasive blood gas analysis.

"End tidal carbon dioxide measurements correlate well with PaCO₂ in nonintubated patients presenting with a variety of underlying problems. Determinations are rapid, inexpensive, and noninvasive, and may obviate the need for arterial blood gases in selected groups of patients."

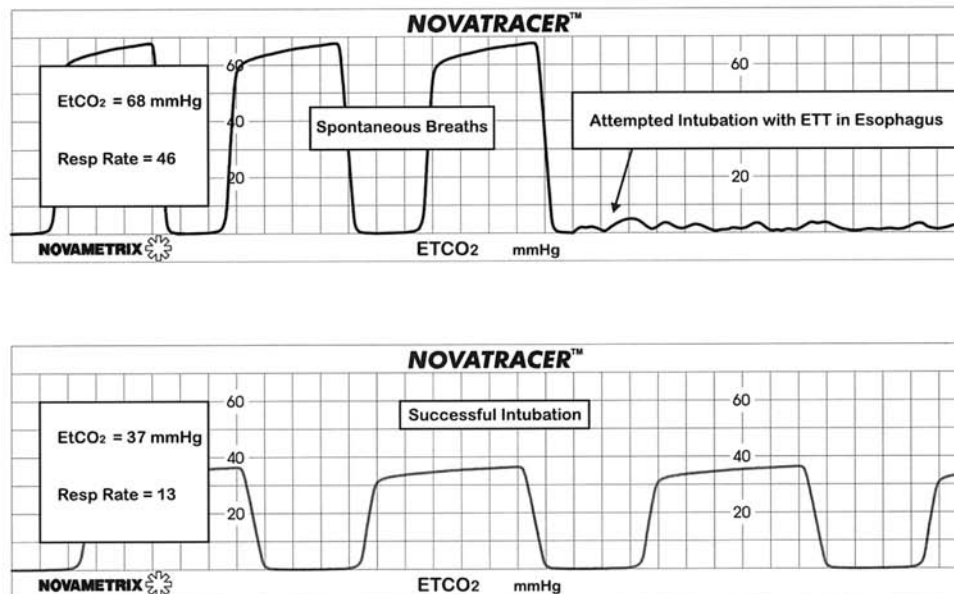
Barton C.W., "Correlation of End Tidal CO₂ Measurements to Arterial PaCO₂ in Nonintubated Patients," Annals of Emergency Medicine, 23:3 562-563, March 1994.

Case Report:

Elderly patient being intubated for severe congestive heart failure

Profile:

A 71 year old woman in congestive heart failure with pulmonary edema is transported from a nursing home to the Emergency Department. Patient has an arterial blood gas drawn with results of pH 7.12, PaCO₂ 68, PaO₂ 44 while receiving 100% oxygen via a non-rebreathing mask. Patient is emergently intubated for impending respiratory failure. The capnograph tracing below illustrates what happens when the endotracheal tube is inadvertently placed into the esophagus. Upon viewing this waveform, the clinician removed the endotracheal tube and replaced it correctly in the trachea.

**Discussion:**

Esophageal intubation is a serious problem and can be difficult to recognize. The use of the *CAPNOGARD*® capnograph provided immediate identification that the endotracheal tube had been placed in the patient's esophagus. Capnography is an excellent tool to quickly and accurately verify proper endotracheal intubation, especially in cases where assessment of breath sounds may be difficult.

"In addition to ensuring proper endotracheal tube position, the waveform can provide evidence of such problems as endotracheal tube obstruction and ventilator circuit malfunction, as well as a variety of clinical disorders, including pulmonary embolism, acute hemorrhage and cardiac arrest."

Asplin B. and White R., "Out-of-Hospital Quantitative Monitoring of End Tidal Carbon Dioxide Pressure During CPR," *Annals of Emergency Medicine*, 23:1 26, January 1994.

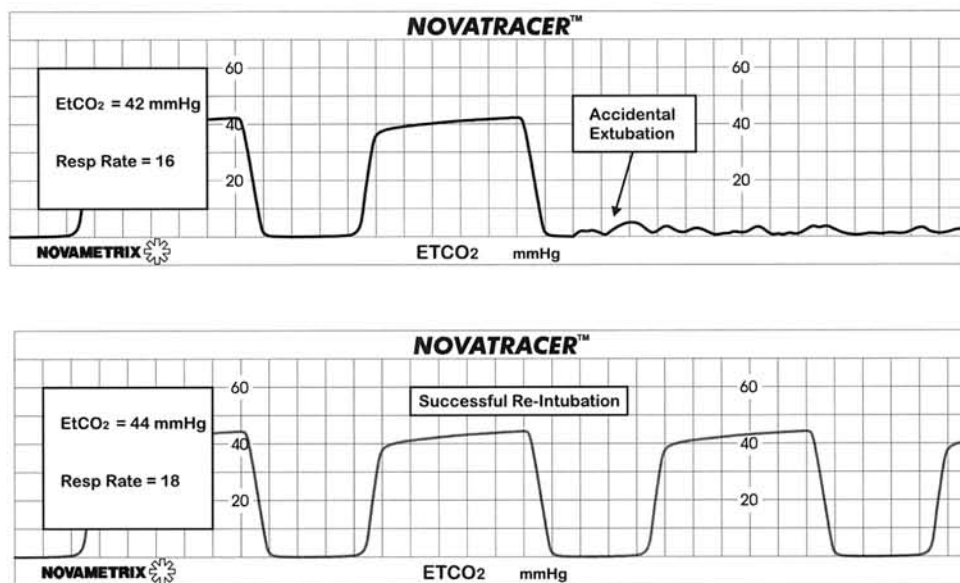


Case Report:

Intubated adult being transported from the Emergency Department to the CT Scan Suite

Profile:

A 47 year old male with multiple head and chest trauma from a motor vehicle accident is admitted to the Emergency Department. Patient is intubated and being ventilated with a hand-resuscitator. Ventilation is being continuously monitored with a mainstream capnograph. During transport to the CT Scan Suite, the capnogram tracing changes dramatically and the ETCO_2 value drops to zero. Once alerted to this change, the physician checks the airway and finds that the endotracheal tube has become dislodged. The endotracheal tube is removed and the patient is rapidly re-intubated. The appearance of a normal capnogram confirms appropriate intubation.



Discussion:

The use of the CAPNOGARD® capnograph provided essential ventilation monitoring during the hectic intra-hospital transport. The capnograph provides the clinician with an outstanding tool for assessment of airway patency and ventilation during a time when monitoring respiratory status is often overlooked.

"End Tidal CO_2 monitoring may develop into the standard of care for critically ill patients both in the hospital and during transport . . . The monitor can assist with patient care both during mechanical and manual ventilation procedures and can assist with the verification of endotracheal tube placement."

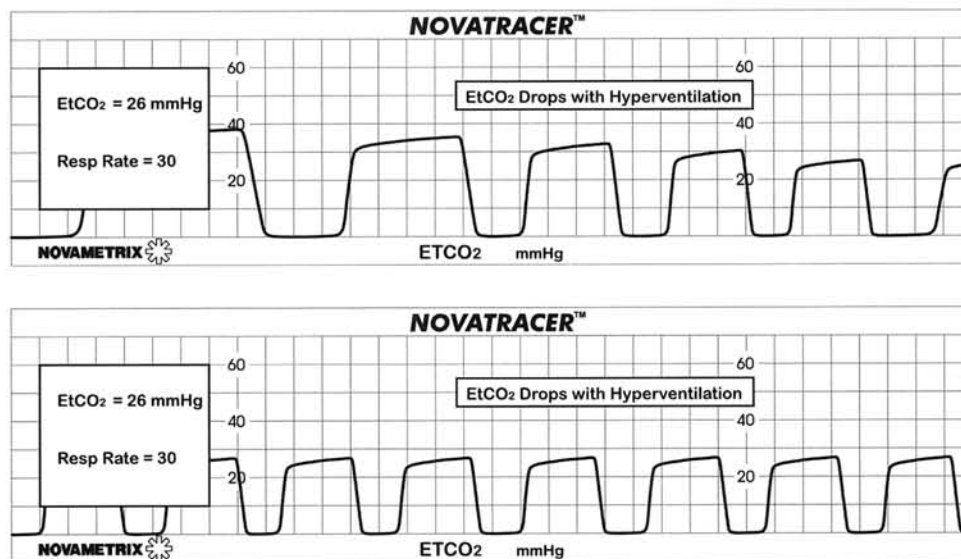
Morris M, "Transport Considerations for the Head-Injured Patient: Are We Contributing to Secondary Injury?," The Journal of Air Medical Transport, 9-13, July 1992.

Case Report:

Patient being hyperventilated for intracranial bleeding

Profile:

An 18 year old male arrives unconscious in the Emergency Department following a 25 foot fall from a bridge. Patient is intubated and taken to CT scan which shows a large subdural hematoma. Patient is placed on a capnograph/pulse oximeter with measurements of SpO_2 96%, ETCO_2 44 mmHg. The physician orders the respiratory therapist to increase the mechanical ventilator rate to maintain an end tidal CO_2 value between 25-30 mmHg.



Discussion:

The use of the $\text{CO}_2\text{SMO}^{\text{®}}$ capnograph/pulse oximeter provided the clinician with a continuous assessment of the ventilator settings required to maintain a prescribed level of hyperventilation. Because PaCO_2 must be maintained in a very narrow range, end tidal CO_2 monitoring is vital in guiding the hyperventilation of head injured patients.

"Hypocapnic cerebral vasoconstriction induced by mechanical hyperventilation is essential for rapid control of elevated intracranial pressure in patients with severe head injuries. The ability to establish rapidly an appropriate degree of cerebral vasoconstriction in the setting of acute head injury depends on an accurate estimation of the minute ventilation (V) that will produce a desired PaCO_2 . End Tidal PaCO_2 monitoring offers a simple, rapid means of estimating PaCO_2 ."

Karagianes T.G., Mackersie R.C., *Critical Care Medicine*, 18:7, 764.

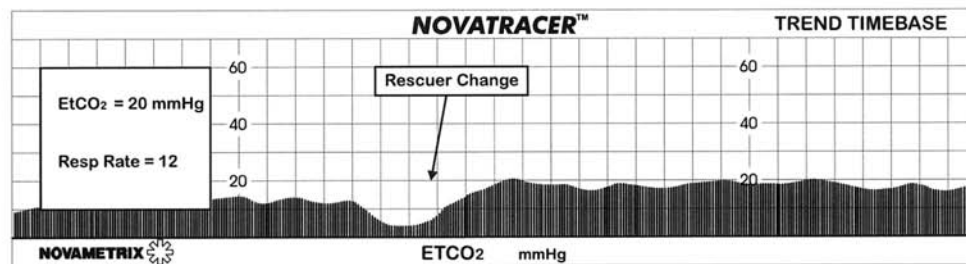


Case Report:

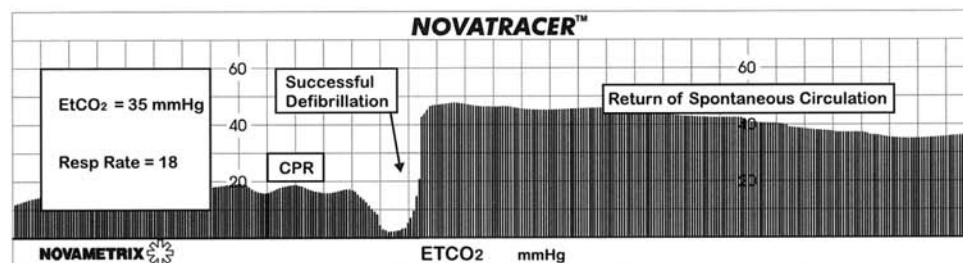
Adult patient in cardiac arrest receiving CPR

Profile:

A 57 year old male admitted to the Emergency Department is in cardiac arrest following an anterior myocardial infarction. Patient has been intubated and is being ventilated with a hand resuscitator. EKG tracings show that the patient is in coarse ventricular fibrillation and has been administered Epinephrine. The patient is connected to a mainstream capnograph which is displaying end tidal CO_2 trends over the past several minutes. By viewing the trend screen, it becomes apparent that end tidal CO_2 falls as the rescuer performing chest compression becomes fatigued.



After approximately 8 minutes of CPR, the patient is successfully defibrillated and functional cardiac rhythm is restored. Immediately upon return of spontaneous circulation there is a dramatic rise in the patient's end tidal CO_2 values.



Discussion:

Continuous monitoring of end tidal CO₂ with the *CAPNOGARD*[®] capnograph during cardiac arrest provided a valuable non-invasive measurement of chest compression effectiveness. End tidal CO₂ correlates with cardiac output; as cardiac output falls so does end tidal CO₂ when spontaneous circulation returns, there will be an immediate increase in end tidal CO₂. The capnograph is also valuable to verify appropriate endotracheal intubation during cardiac arrest.

“ . . . that measurement of the end-tidal carbon dioxide concentration may be a practical, non-invasive method for monitoring blood flow generated by precordial compression during cardiopulmonary resuscitation and an almost immediate indicator of successful resuscitation.”

Falk J.L., Rackow E.C., Weil M.H., “End-tidal Carbon Dioxide Concentration During Cardiopulmonary Resuscitation,” New England Journal of Medicine, 318(10): 607-11, March 10, 1988.

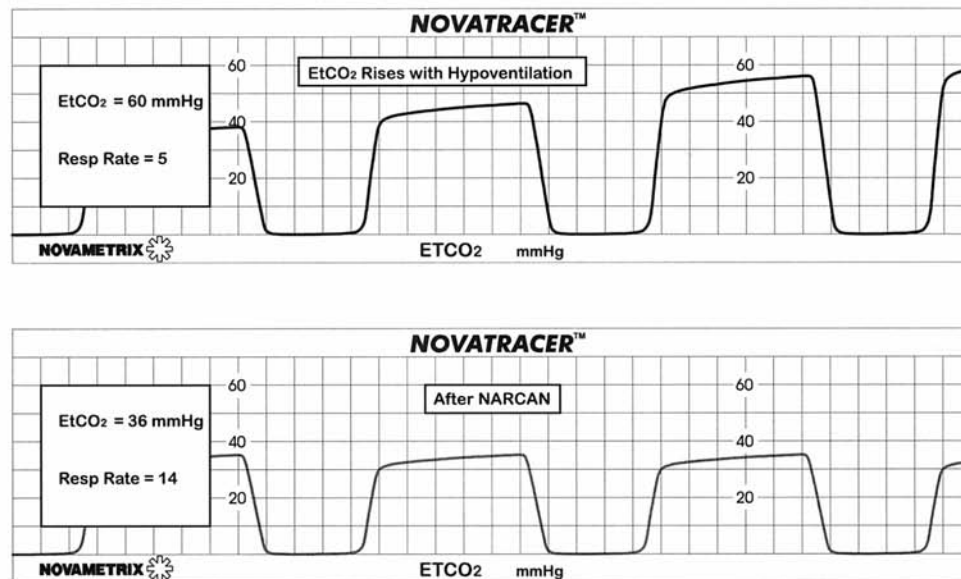


Case Report:

Patient receiving pain medication for a gunshot wound

Profile:

A 23 year old male is admitted to the Emergency Department with a gunshot wound to the lower right leg. Patient is given an injection of Morphine Sulfate for pain management prior to transport to the Operating Room for surgical repair. Patient is placed on a capnograph/pulse oximeter via a nasal CO₂ cannula, with results of Heart Rate 112, Respiratory Rate 5, SpO₂ 88% and ET_{CO}₂ 60 mmHg. Narcan is administered to reverse the respiratory depression caused by the Morphine. The reversal of respiratory depression is reflected by a decrease in ET_{CO}₂ to a normal level of 36 mmHg.



Discussion:

Patients requiring conscious sedation are at risk of developing respiratory depression. The CO₂SMO® capnograph/pulse oximeter will detect apnea or other changes in the respiratory pattern. Pulse oximetry aids in the detection of unrecognized hypoxemia.

"One patient developed clinically significant apnea after the procedure that was picked up by the apnea alarm, and eight additional patients developed clinically silent hypoxemia and increased PETCO₂ during the procedure."

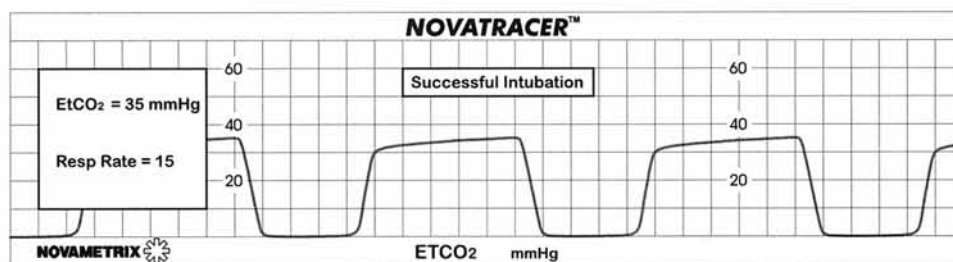
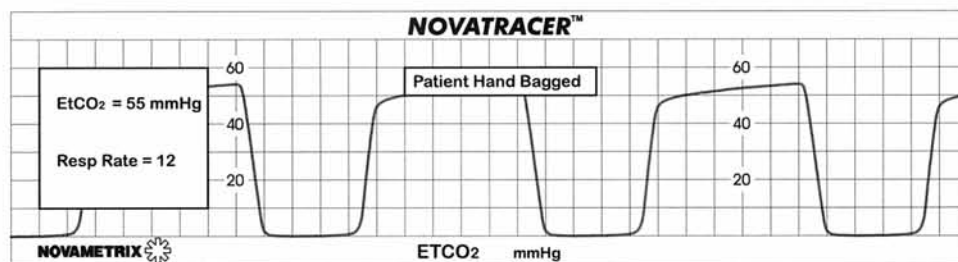
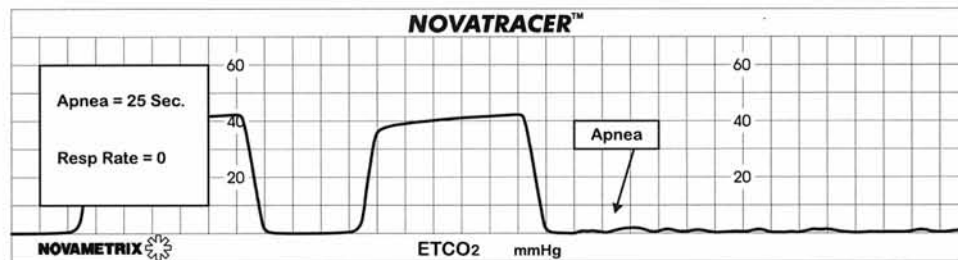
Wright S.W., "Conscious Sedation in the Emergency Department: The Value of Capnography and Pulse Oximetry," *Annals of Emergency Medicine*, 21(5): 551-5, May 1992.

Case Report:

Patient becomes apneic during placement of central line

Profile:

A 44 year old woman is admitted to the Emergency Department following a motorcycle accident. Patient is conscious and has multiple chest and abdominal injuries with vital signs of Heart Rate 142, BP 68/37 and Respiratory Rate 20 and shallow. The patient is placed on a capnograph/pulse oximeter via a nasal CO₂ cannula, with results of SpO₂ 91% and ETCO₂ 45 mmHg. The patient appears to have a large amount of blood loss and the decision is made to place a central line in the jugular vein for fluid resuscitation. The patient's neck is cleaned and prepped and the head, neck and chest are draped to create a surgical field. The physician administers Versed® IV (midazolam HCL) to the patient immediately prior to making the neck incision. Approximately 3 minutes after the Versed is given, the capnograph alerts the physician by alarming for no respiration. The patient is ventilated with a manual resuscitator and then intubated to ensure a patent airway.



Discussion:

Many procedures performed in the Emergency Department require conscious sedation. These patients have special monitoring needs because of the risk of apnea. The *CO₂SMO*[®] capnograph/pulse oximeter using the sampling tube is especially helpful in situations where the head, neck and chest are draped and cannot be easily visualized.

“The use of pulse oximetry is recommended for the detection of unrecognized hypoxemia during conscious sedation. Capnography by nasal cannula appears to be a useful modality in monitoring during conscious sedation . . .”

Wright S.W., “Conscious Sedation in the Emergency Department: The Value of Capnography and Pulse Oximetry,” Annals of Emergency Medicine, 21(5): 551-5, May 1992.

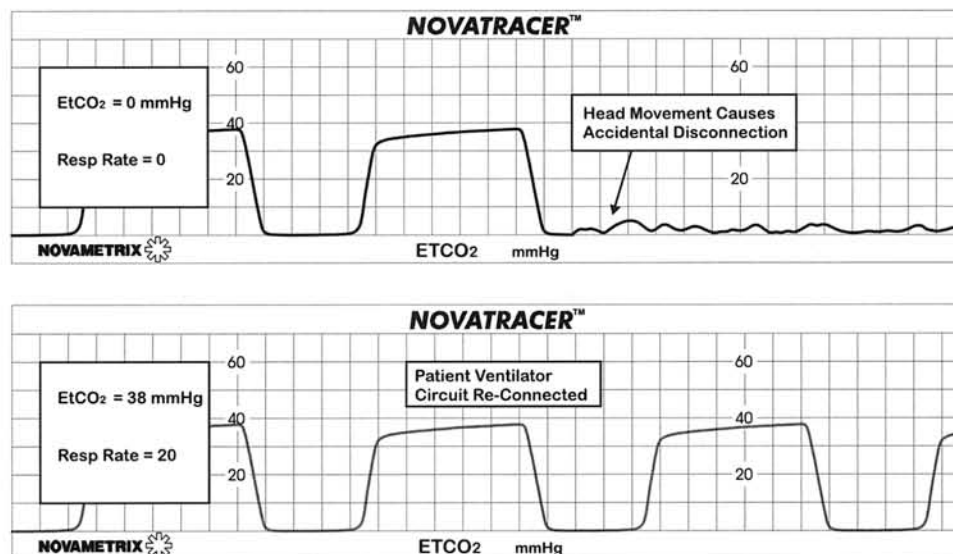


Case Report:

Accidental patient disconnect during mechanical ventilation in the Emergency Department

Profile:

A 34 year old male is admitted to the Emergency Department following a drug overdose of alcohol and Valium™. Patient is intubated, mechanically ventilated and monitored with a capnograph. As the patient starts to regain consciousness, he moves his head erratically and causes the ventilator to become disconnected from the endotracheal tube. Immediately, the capnograph alarms to signal the accidental disconnect, however there are no alarms from the mechanical ventilator. The Y-piece of the ventilator circuit has fallen under the patient's arm and the ventilator is still generating enough pressure to meet the requirements of the ventilator's low pressure alarm. The patient is reconnected to the ventilator and a normal CO₂ value and CO₂ waveform return.



Discussion:

With increasing shortages of ICU beds, short term mechanical ventilation is often performed in the Emergency Department. Many ventilator alarm systems can be inadvertently defeated and alarm conditions may go undetected. The CAPNOGARD® capnograph is a valuable tool to assess changes in cardiopulmonary status as well as alert the clinician to possible mechanical ventilator failures.

"Recent advances in technology provide non-invasive, continuous monitoring of end-organ function by using pulse oximeters to measure the oxygen saturation of hemoglobin, and capnographs to measure end tidal carbon dioxide"

"CO₂ analysis in the ventilator circuit can provide a disconnection alarm that is particularly sensitive and responds rapidly."

U.S. Department of Health and Human Services, Public Health Services, Food and Drug Administration, "Increasing Early Detection of Accidental Disconnections."

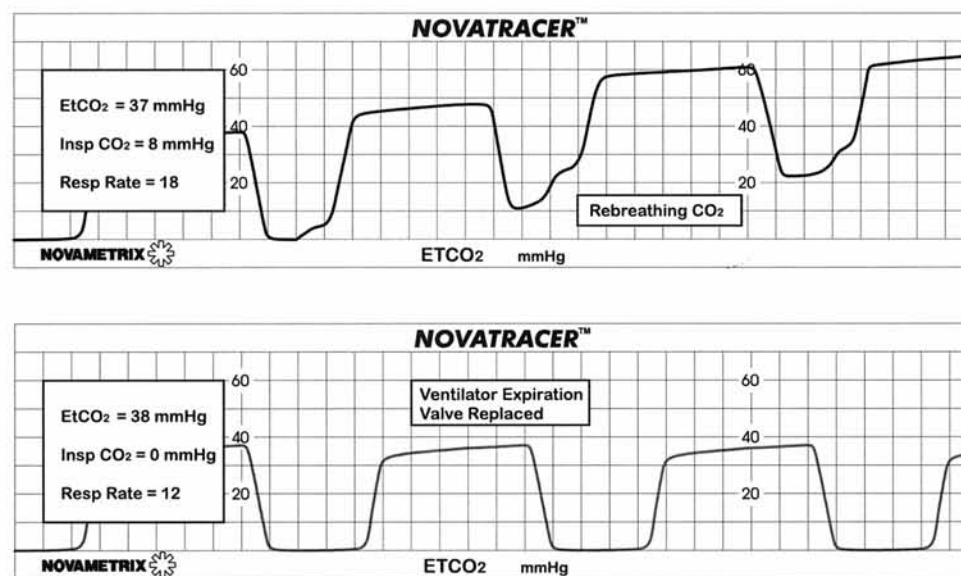


Case Report:

Patient in respiratory failure on a mechanical ventilator awaiting transport to the Intensive Care Unit

Profile:

A 64 year old female with emphysema is intubated and placed on a mechanical ventilator for acute respiratory failure. Patient is in the Emergency Department waiting for a bed in the Medical Intensive Care Unit. Patient is being monitored with a capnograph/pulse oximeter. After being placed on the mechanical ventilator, the nurse notes a high inspired CO_2 value and a rising baseline of the CO_2 waveform is observed. The clinician is immediately alerted to the fact that the patient is rebreathing CO_2 due to a defective ventilator valve. The ventilator valve is replaced and the CO_2 waveform returns to baseline, indicating that normal ventilation has resumed.



Discussion:

Recently, it has become common for mechanical ventilation to be performed in the Emergency Department due to a shortage of ICU beds. The $\text{CO}_2\text{SMO}^{\text{®}}$ capnograph/pulse oximeter is an excellent monitoring tool to alert the clinician to unexpected changes in cardiopulmonary status or technical failures for patients on mechanical ventilators.

"In this case, the PSRV was ruptured, causing loss of gas from the ventilator during both inspiration and exhalation. The ventilatory effect was a reduction of tidal volume, peak airway pressure, and minute ventilation, with resulting hypercarbia."

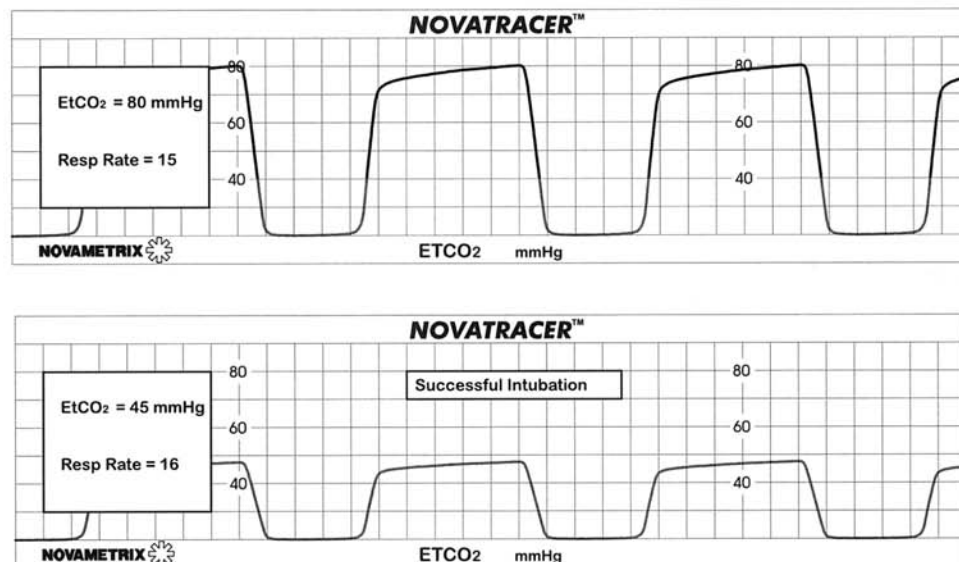
Sommer R.M., Bhalla G.S., Jackson J.M., Cohen M.I., "Hypoventilation Caused by Ventilator Valve Rupture," *Anesthesia Analgesia*, 67: 999-1001, 1988.

Case Report:

Patient in congestive heart failure being transported to the Emergency Department

Profile:

A 68 year old women with congestive heart failure is being transported from home to the Emergency Department via ambulance. Patient is lethargic and has vital signs of Heart Rate 136, BP 102/53 and Respiratory Rate 15. Patient is receiving 100% oxygen via a non-rebreathing mask and is placed on a capnograph/pulse oximeter with results of SpO₂ 82% and ET_{CO}₂ 74 mmHg. During transport to the hospital, the patient becomes unconscious and ET_{CO}₂ rises to 80 mmHg. The decision is made to intubate the patient. The patient is successfully intubated and CO₂ levels return to normal values.



Discussion:

Capnography and pulse oximetry assisted in the immediate diagnosis and treatment of the patient's impending respiratory failure. Capnography is valuable to verify appropriate endotracheal tube intubation and to ensure ongoing airway patency and ventilation.

"The esophageal CO₂ concentrations were very low initially, compared to the tracheal recordings, and carbon dioxide completely disappeared after a few ventilations into the esophagus, distinguishing between the tracheal and esophageal capnography tracings was easy."

Linko K., Paloheimo M., Tammisto T., "Capnography for Detection of Accidental Esophageal Intubation", *ACTA Anaesthesiologica Scandinavica*, 27(3): 199-202, June 1983.

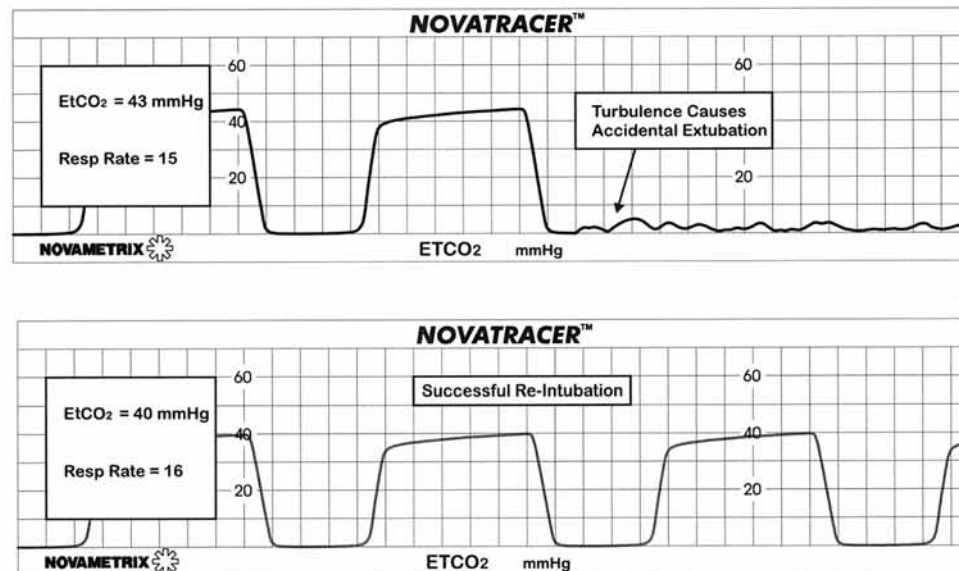


Case Report:

Helicopter transport of an intubated adult following a motor vehicle accident

Profile:

A 32 year old male is transported via helicopter from the scene of a motor vehicle accident to a regional trauma center. Patient has multiple trauma including a flail chest requiring intubation and mechanical ventilation. Approximately 7 minutes into the flight, the helicopter begins to shake violently due to unexpected turbulence. The low CO_2 alert on the capnograph signals the flight nurse to check the patient's airway. The endotracheal tube had become dislodged as indicated by the capnograph tracing. The patient is quickly reintubated and appropriate intubation is confirmed by the presence of a normal CO_2 waveform.



Discussion:

Use of the combination capnograph/pulse oximeter immediately alerted the Flight Crew that the patient had become extubated. Capnography provides an excellent tool to evaluate ventilation during helicopter transports where conventional assessment techniques are difficult or impossible to implement.

"Team members' ventilation technique is altered with capnometry feedback and its use in air medical transport improves the team member's maintenance of the head injured patient's ETCO₂ within specific parameters."

Morris M. and Kinkade S., "Effects of Capnometry on Team Member's Technique of Manual Ventilation for the Head Injured Patient During Prehospital Transport," Presented at Air Medical Transport Meeting, Detroit, MI, 1994.



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