Method of $ETCO_2$ Monitoring Affects Accuracy while Administering CPAP

Marshall Washick, NREMT-P, Keith Wesley, MD, FACEP, Brian Crawley, NREMT-P

Introduction

End-tidal carbon dioxide ($ETCO_2$) monitoring (capnography) is the standard of care for the intubated patient.[1] Advances in technology now permit capnography in the spontaneously breathing patient through the use of side-stream sampling of the patient's exhaled gases.[2]

The benefit of capnography in the patient with respiratory distress has been well documented and its use in EMS is strongly encouraged.[3]

Coincidentally, pre-hospital use of CPAP for respiratory distress has increased in recent years. However, to date, there have been no studies to determine the affect, if any, that CPAP devices have on both the accuracy of and ability to perform capnography while administering CPAP despite the fact that CPAP manufacturers purport to permit capnography through various methods.

The aim of this study was to determine if $ETCO_2$ monitoring is affected by these various CPAP manufacturer recommended methods.

Materials

CPAP devices: Whisper Flow, Port-O-Vent, Boussignac

Monitoring: Nonin Life Sense Monitor (pulse oximetry and capnography capture), Nonin Life Sense Bluetooth Terminal

Nonin Life Sense Monitor

Life Sense Bluetooth Terminal

Methods

Twelve healthy subjects between the ages of 20-50 were enrolled. Multiple measuring methods were analyzed: nasal cannula, split oral-nasal cannula (both under CPAP mask), in-line port, and exhalation port on each device. Each subject was exposed to 5 minutes of CPAP at 5 cm H_2O pressure for each method of measurement. Vital signs were obtained for 5 minutes prior to and after administration of CPAP to establish a baseline and allow for a return to baseline following each method.

The Whisper Flow and Port-O-Vent had four methods of measurement while the Boussignac only had three due to its unique design. Peak $ETCO_2$ levels and waveforms were captured simultaneously via Bluetooth using Life Sense software. Values obtained were compared using Student T test.

Capongraphy waveforms were qualitatively compared by the authors for clinical acceptance.

The study received IRB approval by HealthEast Care System and was funded by an unrestricted educational grant from Nonin Medical Inc.

Whisper Flow in-line

Port-O-Vent in-line

Bousignac in-line

Split oral-nasal cannula

Cannula under CPAP mask

Results

There was no statistical difference in resting HR, RR, or $ETCO_2$ for all volunteers. The $ETCO_2$ results are listed in table 1 with mean and (S.D.).

Table 1	Nasal Cannula	Split Cannula	In-line	Exhalation Port
Baseline	37.2 (6.1)			
Whisper Flow	33.9 (4.8)	31.7 (5.4)	6.1 (5.9) *	1.9 (5.3) *
Port-O-Vent	32.7 (5.6)	36.0 (5.4)	27.7 (8.4)*	10.3 (15.5) *
Boussignac	36.8 (3.6)	35.1 (5.7)	37.1 (4.3)	

* $P < 0.05$

Two of the three (Whisper Flow and Port-O-Vent) devices demonstrated significant degradation in accuracy with in-line and exhalation port sampling. The waveforms obtained by in-line and exhalation port sampling were uniformly graded clinically unacceptable.

There was no instances of mask-face seal leaks with the use of either cannula with all three devices.

Discussion

The use of CPAP by EMS has been shown to significantly decrease the need for intubation in patients with respiratory distress. While traditional training emphasizes level of consciousness and work of breathing as indicators of impending respiratory failure capnography is the standard of care for detecting such events in both the emergency and procedural sedation arena.

Therefore, it follows that $ETCO_2$ monitoring should be used in combination with CPAP to assess the impact of treatment and herald impending respiratory failure.

Monitoring must be accurate and provide clinically useful waveforms. This study demonstrated that port sampling does not permit waveform analysis.

CPAP devices differ significantly in their flow dynamics. The Whisper Flow and Boussignac are constant flow delivery systems while the Port-O-Vent is a demand flow system. We believe that the slight decrease in accuracy of both cannulas with the Whisper Flow is a reflection of "wash-out" phenomenon. Patients in respiratory distress preferentially breathe through their mouths which would further support the use of the split oral-nasal cannula with any CPAP device.

Limitations

This study was limited by the use of healthy adult subjects with normal, uncompromised tidal volumes. Further research is needed to determine if the dynamic tidal volumes observed in respiratory distress will also affect capnography accuracy.

Conclusion

The accuracy of capnography is significantly affected by the method by which $ETCO_2$ is sampled. The use of a split oral-nasal cannula provides consistently reliable sampling in the three most commonly used commercial CPAP devices and waveform analysis is only possible with use of a cannula under the CPAP mask.

Literature Cited

1. NAEMSP Position Paper "Verificaytion of Endotracheal Tube Placement Following Intubation", Robert E. O'Connor, MD, MPH, Robert A. Swor, DO, for the National Association of EMS Physicians Standards and Clinical Practice Committee, Prehospital Emergency Care, July/Sept 1999 Volume 3/Number 3
2. "Capnography: A ValuableTool for Airway Management", Joshua Nagler, MD, Baruch Krauss, MD, EdM, Emerg Med Clin N Am 26 (2008) 881–897
3. "Measurement of end-tidal carbon dioxide in spontaneously breathing patients in the pre-hospital setting. A prospective evaluation of 350 patients", B.M. Wahlen, T. Bey, B.B. Wolke, Resuscitation 56 (2003) 35/40