Microstream®

Clinical Resources

Standards and Bibliography for the Clinical Use of Capnography

Welch Allyn®

Oridion®

Table of Contents

Standards

ACEP (American College of Emergency Physicians)

2009

ACEP Policy Statement Revised and approved by the ACEP Board of Directors April 2009.

ETT Placement

End-tidal carbon dioxide detection is the most accurate technology to evaluate endotracheal tube position in patients who have adequate tissue perfusion. Properly placed endotracheal tubes may become displaced due to movement of patients and/or equipment. Continuous assessment of correct endotracheal tube placement with continuous end-tidal carbon dioxide monitoring is ideal.

2005

Godwin SA, Caro DA, Wolf SJ, Jagoda AS, Charles R, Marett BE, Moore J, American College of Emergency Physicians. Clinical policy: procedural sedation and analgesia in the emergency department. Ann Emerg Med 2005 Feb;45(2):177-96.

Sedation in the Emergency Department

Capnometry is a technique used to monitor $etCO_2$ and, therefore, may detect early cases of inadequate ventilation before oxygen desaturation takes place. An increase in $etCO_2$ might be the only clue to hypoventilation and potential respiratory compromise. The authors conclude that in the presence of $etCO_2$ monitoring, these identifiers may allow more rapid identification of hypoventilation than pulse oximetry alone. In the study, pulse oximetry would have identified only 11 of the 33 patients meeting the predetermined definitions for respiratory depression of an oxygen saturation less than 90%, $etCO_2$ of greater than 50 mm Hg, or an absent waveform. Interventions and practices considered: Pulse oximetry and capnometry if indicated How should respiratory status be assessed? Consider capnometry to provide additional information regarding early identification of hypoventilation.

Standard physical examination methods, such as auscultation of lungs and epigastrium, visualization of chest movement and fogging in the tube, are not sufficiently reliable to exclude esophageal intubation in all situations. End-tidal CO_2 detection, either qualitative, quantitative or continuous, is the most accurate and easily available method to monitor correct endotracheal tube position in patients who have adequate tissue perfusion. Pulse oximetry and esophageal detector devices are not as reliable as end-tidal CO_2 determinations in patients who have adequate tissue perfusion.

Michael L. Carius, President of ACEP. "This new policy supports the use of carbon dioxide monitoring as the most effective method of confirming that patients have been intubated correctly."

Consider capnometry to provide additional information regarding early identification of hypoventilation.

2001

Among prehospital providers, reports of missed intubations range between 0-5%, although a recent study demonstrated a substantially higher rate (25%) of misplaced endotracheal tubes when patients intubated in the field were re-evaluated upon presentation to the emergency department.

Pulse oximetry alone is inadequate because desaturation as a marker for a misplaced endotracheal tube can be a late finding depending on the amount of pre-oxygenation the patient has undergone.

Emergency Department

ACEP (American College of Emergency Physicians) cont.

End-tidal CO_2 detection approaches 100% sensitivity and specificity in the patient with spontaneous circulation.Several professional organizations including the American Society of Anesthesiologists, the National Association of EMS Physicians, and the American Heart Association recommend utilizing secondary tube confirmation techniques such as end-tidal CO_2 measurements.

AHA (American Heart Association)

2005

Although end-tidal CO_2 serves as an indicator of cardiac output produced by chest compressions and may indicate return of spontaneous circulation (ROSC), there is little other technology available to provide real-time feedback on the effectiveness of CPR. End-tidal CO_2 monitoring is a safe and effective noninvasive indicator of cardiac output during CPR and may be an early indicator of ROSC in intubated patients. End-tidal CO_2 monitoring during cardiac arrest can be useful as a noninvasive indicator of cardiac output generated during CPR (Class IIa). In the patient with ROSC, continuous or intermittent monitoring of end-tidal CO_2 provides assurance that the endotracheal tube is maintained in the trachea. End-tidal CO_2 can guide ventilation, especially when correlated with the $PaCO_2$ from an arterial blood gas measurement.

2005

To reduce the risk of unrecognized tube misplacement or displacement, providers should use a device such as an exhaled CO_2 detector or an esophageal detector device to confirm endotracheal tube placement in the field, in the transport vehicle, on arrival at the hospital, and after any subsequent movement of the patient.

2000

Emergency responders must confirm tracheal tube position by using nonphysical examination techniques.

ENA (Emergency Nurses Association)

2009

Emergency Nursing Resource: The Use of Capnography During Procedural Sedation/Analgesia in the Emergency Department

Conclusions and recommendations about the use of capnography for procedural sedation and analgesia (PSA) in adults and children in the emergency department:

· Capnography is a useful technique for detecting respiratory depression during and after PSA.

· $EtCO_2$ is a more sensitive indicator of respiratory depression than SpO_2 or clinician assessment during PSA as well as in the recovery phase…

· Capnography is a useful adjunct for monitoring patients during PSA in the emergency department (Level B).

2005

Patients undergoing sedation and analgesia require frequent assessments of their vital signs such as heart rate, blood pressure, respiratory rate, and pulse oximetry; cardiopulmonary status including cardiac monitoring, breath sounds, skin color, oxygen saturation, and exhaled carbon dioxide.

SCCM (The Society of Critical Care Medicine)

2003

The measurement of exhaled carbon dioxide is the best signal of return of spontaneous circulation during CPR. Capnography is also a useful noninvasive index of the adequacy of pulmonary perfusion during closed-chest cardiac compression. Moreover, the quantitative measurement of end-tidal PCO_2 may have predictive value during CPR.

Bibliography

General

End-tidal carbon dioxide monitoring during procedural sedation. Miner JR, Heegaard W, Plummer D. Academic Emergency Medicine. April 2002; Vol. 9, No. 4, 275-280.

Effect of mask type, oxygen concentration, and flow rate on both exhaled CO_2 and respiratory frequency measurement by capnograph. Nuccio PF, Spada CT, Weinhouse GL, Niebel KH, Waugh JB. Respiratory Care. November 2008; Vol. 53(11), 1578.

Capnography for procedural sedation and analgesia in the emergency department. Krauss B, Hess DR. Annals of Emergency Medicine. August 2007; Vol. 50(2), 172-181.

15-second triage tool: The use of capnography for the rapid assessment & triage of critically injured patients & victims of chemical terrorism. Krauss B, Heightman AJ. Journal of Emergency Medical Services. June 2006; Vol. 31(6), 60-68.

Utility of a novel quantitative handheld microstream capnometer during transport of critically ill children. Singh S, Allen WD, Venkataraman ST, Bhende MS. The American Journal of Emergency Medicine. May 2006; Vol. 24, Issue 3, 302-307.

Capnography: Considerations for its use in the emergency department. Anderson MR. Journal of Emergency Nursing. April 2006; Vol. 32, Issue 2, 149-153.

Shortness of Breath

A study on the use of nasal capnometry in patients presented with acute breathlessness in the emergency department. Ab-Rahman NH, Mamat AF, Ahmad R, Noh AY, Jaalam K. Annals of Emergency Medicine. April 2008; Vol. 51, Issue 4, 534-535.

Airway Obstruction

A comparison of capnographic waveform indices and peak flow meter in the monitoring of asthmatic patients in emergency departments. Ab-Rahman NH, Howe TA. Annals of Emergency Medicine. April 2008; Vol. 51, Issue 4, 476-477.

Expiratory capnogram assessing bronchospasm versus expiratory peak flow. Hysham H Sr., Claude BJ Sr., Bruno C Sr. Annals of Emergency Medicine. April 2008; Vol. 51, Issue 4, 534.

Capnography as a determinate of ventilatory status for out-of-hospital obtunded patients. Martin DL, Silvestri S, Papa L, Ralls GA, Krauss B. Annals of Emergency Medicine. September 2007; Vol. 50, Issue 3 (Suppl.), S92.

Emergency Department

Cardiopulmonary Failure and Arrest

Computerized continuous capnography for prediction of survival from resuscitation. Einav S, Matot I. Resuscitation - Journal of the European Resuscitation Council. May 2008; Vol. 77 (Suppl.), S34.

Capnography versus impedance: In search of an optimal strategy for ventilation detection during cardiopulmonary resuscitation. Edelson D, Eilevstjonn J, et al. Resuscitation - Journal of the European Resuscitation Council. May 2008; Vol. 77 (Suppl.), S3.

Nasal capnography monitoring: Making sedation safer in the emergency department. McNaughton GW, Stewart G. Annals of Emergency Medicine. April 2008; Vol. 51, Issue 4, 548-549.

Emergency department capnographic confirmation of endotracheal tube position in out-of hospital cardiac arrest patients. Silvestri S, Krauss B. Annals of Emergency Medicine. September 2007; Vol. 50, Issue 3 (Suppl.), S4.

Predicting the need for hospitalization in acute childhood asthma using end-tidal capnography. Kunkov S, Pinedo V, Silver EJ, Crain EF. Pediatric Emergency Care. September 2005; Vol. 21, No. 9, 574-577.

Diabetes

Predicting diabetic ketoacidosis in children by measuring end-tidal CO_2 via non-invasive nasal capnography. Gilhotra Y, Portor P. Journal of Paediatrics and Child Health. October 2007; Vol. 43, No. 10, 677-680.

Intubation

The effectiveness of out-of-hospital use of continuous end-tidal carbon dioxide monitoring on the rate of unrecognized misplaced intubation within a regional emergency medical services system. Silvestri S, Ralls GA, Krauss B, Thundiyil J, Rothrock SG, Senn A, Carter E, Falk J. Annals of Emergency Medicine. May 2005; Vol. 45, Issue 5, 497-503.

Sedation

The utility of supplemental oxygen during emergency department procedural sedation with propofol: A randomized, controlled trial. Deitch K, Chudnofsky CR, Dominici P. Annals of Emergency Medicine. July 2008; Vol. 52, Issue 1, 1-8.

Capnography for procedural sedation and analgesia in the emergency department. Krauss B, Hess DR. Annals of Emergency Medicine. August 2007; Vol. 50(2), 172-181.

Does end-tidal carbon dioxide monitoring detect respiratory events prior to current sedation monitoring practices? Burton JH, Harrah JD, Germann CA, Dillon DC. Academic Emergency Medicine. May 2006; Vol. 13(5), 500-504.

End-tidal carbon dioxide monitoring during procedural sedation. Miner JR, Heegaard W, Plummer D. Academic Emergency Medicine. April 2002; Vol. 9(4), 275-280.

Standards

ASA (American Society of Anesthesiologists)

2009

Both the consultants and the ASA members disagree that pulse oximetry monitoring is more likely to detect respiratory depression than are clinical signs.

The consultants and ASA members both agree that end-tidal carbon dioxide monitoring is more likely to detect hypercapnia/hypercarbia and respiratory depression than are clinical signs.

Detection of Respiratory Depression

All patients receiving neuraxial opioids should be monitored for adequacy of ventilation (e.g., respiratory rate, depth of respiration [assessed without disturbing a sleeping patient]), oxygenation (e.g., pulse oximetry when appropriate), and level of consciousness.

2005

Practice Guidelines for the Perioperative Management of Patients with Obstructive Sleep Apnea (OSA)

These guidelines focus on the perioperative management of patients with OSA who may be at risk for perioperative morbidity and mortality because of potential difficulty in maintaining a patent airway. For patients at increase perioperative risk from OSA, the following is recommended...

III. Intraoperative Management...The consultants agree that respiratory CO_2 monitoring should be used during moderate or deep sedation in these patients...

Recommendations

If moderate sedation is used, ventilation should be continuously monitored by capnography or another automated method if feasible because of the increased risk of undetected airway obstruction in these patients.

IV. Postoperative Management…Postoperative concerns in the management of patients with OSA include...the exacerbation of respiratory depression may occur on the third or fourth postoperative day as sleep patterns are reestablished and "REM rebound" occurs.

2004

Statement on the Safe Use of Propofol approved by the ASA House of Delegates, October 2, 2004

"During the administration of propofol, patients should be monitored without interruption to assess levels of consciousness, and to identify early signs of hypotension, bradycardia, apnea, airway obstruction and /or oxygen desaturation. Ventilation, oxygen saturation, heart rate and blood pressure should be monitored at regular and frequent intervals. Monitoring for the presence of exhaled carbon dioxide should be utilized when possible, since movement of the chest will not dependably identify airway obstruction or apnea."

2002

Practice Guidelines for Sedation and Analgesia by Non-Anesthesiologists "In circumstances where patients are physically separated from the care giver, the Task Force believes that automated apnea monitoring (by detection of exhaled CO_2 or other means) may decrease risks during both moderate and deep sedation…" "Monitoring of exhaled CO_2 should be considered for all patients receiving deep sedation and for patients whose ventilation cannot be directly observed during moderate sedation."

Procedural Sedation

Joint Statement: The American Association for the Study of Liver Diseases, American College of Gastroenterology, American Gastroenterological Association, and American Society for Gastrointestinal Endoscopy

2009

GASTROENTEROLOGY December, 2009;137:2161–2167.

The use of nonanesthesiologist-administered propofol (NAAP) for GI endoscopy

Capnography is recommended when it is difficult to visually assess respiration or during prolonged procedures such as ERCP and EUS. In these clinical settings, capnography has been shown to significantly reduce the incidence of hypoxemia and apnea. Capnography reduces the occurrence of apnea and hypoxemia during ERCP/EUS (grade 2B) and upper endoscopy/colonoscopy (grade 2C).

ASGE (American Society for Gatrointestinal Endoscopy)

2008

Guideline; Sedation and anesthesia in GI endoscopy GASTROINTESTINAL ENDOSCOPY, Volume 68, No. 5 : 2008; 815-826.

Recommendations for propofol use during endoscopy

Monitoring oxygenation by pulse oximetry is not a substitute for monitoring ventilatory function. Capnography should be considered because it may decrease the risks during deep sedation. Continuous monitoring will allow recognition of patients who have progressed to a deeper level of sedation.

Respiratory Depression

Given that hypoxemia resulting from depressed respiratory activity is a principal risk factor for adverse respiratory events during sedation, integrating capnography into patient monitoring protocols may improve safety.

It more readily detects hypoventilation compared with pulse oximetry or visual observation and thereby provides an opportunity for early recognition of depressed respiratory activity. Data are available, however, to support its use during ERCP and EUS. A recent randomized controlled trial using the combination of an opioid and benzodiazepine for elective ERCP and EUS found significantly less hypoxemia in the subjects who received sedation with capnography compared with standard monitoring.

2003

Capnography more readily identifies patients with apneic episodes and when used to guide sedation results in less CO_2 retention. Capnography is a superior way to evaluate ventilation, compared with pulse oximetry measurement, which assesses oxygenation.

CSA (California Society of Anesthesiologists)

2008

CSA Guidelines for Deep Sedation by Non-Anesthesiologists; May, 2008.

Adequacy of ventilation

Non-Anesthesiologists Sedation Practitioners, Supervised Sedation Professionals, Education and Training

Monitoring and recognizing abnormalities of physiologic variables, including the following: Capnographic monitoring. The health professional should be familiar with the use and interpretation of capnographic waveforms to determine the adequacy of ventilation during deep sedation.

Joint Commission

2008

Joint Commission Accreditation Program: Hospital Chapter: Provision of Care, Treatment, and Services, 2008; Standard PC.03.01.01

Elements of Performance for PC.03.01.01

1. Individuals administering moderate or deep sedation and anesthesia are qualified and have credentials to manage and rescue patients at whatever level of sedation or anesthesia is achieved, either intentionally or unintentionally.

2006

Provision of Care, Treatment, and Services

The Administration of Moderate or Deep Sedation or Anesthesia

The standards for sedation and anesthesia care apply when patients in any setting receive, for any purpose, by any route, the following:

- General, spinal, or other major regional anesthesia

Or

- Moderate or deep sedation (with or without analgesia) that, in the manner used, may be reasonably expected to result in the loss of protective reflexes

These protocols are consistent with professional standards and address at least the following: Appropriate monitoring of vital signs, including, but not limited to, heart rates and oxygenation, using pulse oximetry equipment, respiratory frequency and adequacy of pulmonary ventilation.

Standard PC.13.30-.40

Patients are monitored during and immediately after the procedure and/or administration of moderate or deep sedation or anesthesia

Elements of Performance

- Appropriate methods are used to continuously monitor oxygenation, ventilation, and circulation during procedures that may affect the patient's physciological status.
- Each patient's physiological status, mental status, and pain level are monitored. Monitoring is at a level consistent with the potential effect of the procedure and/or sedation or anesthesia.

Bibliography

Does end tidal CO_2 monitoring during emergency department procedural sedation and analgesia with propofol decrease the incidence of hypoxic events? A randomized, controlled trial. Deitch K, Miner J, et al. Annals of Emergency Medicine. September 2009.

Capnographic monitoring of respiratory activity improves safety of sedation for endoscopic cholangiopancreatography and ultrasonography. Qadeer M, Vargo J, et al. Gastroenterology. May 2009; Vol. 136(5), 1568-1576.

Assessment of end tidal carbon dioxide during pediatric and adult sedation for endoscopic procedures. Yarchi, et al. Gastrointestinal Endoscopy. April 2009; Vol. 69, Issue 4, 877-882.

Monitoring to improve ventilation safety during sedation and analgesia. Waugh J, Khodneva Y, Epps CA. Anesthesia and Analgesia. April 2008; Vol. 106, No. 4S.

Detection of respiratory depression prior to evidence of hypoxemia in procedural sedation. Bazin JE. Respiratory Care. November 2007; Vol. 52, No. 11, 1568.

Research advances in procedural sedation and analgesia. Green SM, Annals of Emergency Medicine. January 2007; Vol. 49, No. 1, 31-36.

Microstream capnography improves patient monitoring during moderate sedation: A randomized, controlled trial. Lightdale JR, Goldmann DA, Feldman HA, Newburg AR, DiNardo JA, Fox VL. Pediatrics. June 2006; Vol. 117, No. 6, e1170-1178.

Does end-tidal carbon dioxide monitoring detect respiratory events prior to current sedation monitoring practices? Burton JH, Harrah JD, Germann CA, Dillon DC. Academic Emergency Medicine. May 2006; Vol. 13, No. 5, 500-504.

Procedural sedation and analgesia in children. Krauss B, Green SM. The Lancet. March 2006; Vol. 367, Issue 9512, 766-780.

Automated graphic assessment of respiratory activity is superior to pulse oximetry and visual assessment for the detection of early respiratory depression during therapeutic upper endoscopy. Vargo JJ, et al. Gastrointestinal Endoscopy. June 2002; Vol. 55, No.7, 826-831.

Capnography in the Gastroenterology Lab. Eisenbacher S, Heard L. Gastroenterology Nursing. March/April 2005; Vol. 28, No. 2, 105-106.

End-tidal carbon dioxide monitoring during procedural sedation. Miner JR, Heegaard W, Plummer D. Academic Emergency Medicine. April 2002; Vol. 9, No. 4, 275-280.

Standards

AARC (American Association for Respiratory Care)

2007

BA 10.0 RESOURCES

10.1.2.5 Capnograph

10.3.3 The bronchoscopy assistant must be trained in monitoring and evaluating the patient's clinical condition as reflected by pulse oximetry, capnography, electrocardiogram, and stability of or changes in mechanical ventilation parameters, and be capable of relating changes in clinical condition to disease state, procedure, or drugs administered for the procedure.

BA 11.0 MONITORING

Patient monitoring should be done before, at regular intervals during, and after bronchoscopy until the patient meets appropriate discharge criteria. For no or minimal sedation, less monitoring is necessary. For moderate and deep sedation, more monitoring should be done. The following should be monitored before, during, and/or after bronchoscopy, continuously, until the patient returns to his pre-sedation level of consciousness. 11.1.5 SpO_2, FIO_2 and $ETCO_2$

2003

Capnography should not be mandated for all patients receiving mechanical support, but it may be indicated for: Evaluation of the exhaled [CO_2], especially end-tidal CO_2; Monitoring severity of pulmonary disease and evaluating response to therapy; as an adjunct to determine that tracheal rather than esophageal intubation has taken place; continued monitoring of the integrity of the ventilatory circuit; evaluation of the efficiency of mechanical ventilatory support; monitoring adequacy of pulmonary, systemic, and coronary blood flow; monitoring inspired CO_2 when CO_2 is being therapeutically administered; graphic evaluation of the ventilatory-patient interface; measurement of the volume of CO_2 elimination to assess metabolic rate and/or alveolar ventilation.

Hazards and Complications: Warns against the addition of excessive weight on the endotracheal tube.

Joint Commission

2009

Goal 16

Improve recognition and response to changes in a patient's condition.

NPSG.16.01.01

The [organization] selects a suitable method that enables health care staff members to directly request additional assistance from a specially trained individual(s) when the [patient]'s condition appears to be worsening. A significant number of critical inpatient events are preceded by warning signs prior to the event. A majority of [patient]s who have cardiopulmonary or respiratory arrest demonstrate clinical deterioration in advance. Early response to changes in a [patient]'s condition by a specially trained individual(s) may reduce cardiopulmonary arrests and [patient] mortality.

Step Down

AAP (American Academy of Pediatrics)

2006

Health care providers should confirm endotracheal tube placement immediately after intubation, during transport and whenever the patient is moved. Exhaled CO_2 should be monitored in patients with an endotracheal tube both in the pre-hospital and hospital settings, as well as during all transport, by using a colorimetric detector or capnography.

2004

Guidelines and Levels of Care for Pediatric Intensive Care Units

Respiratory Equipment

Mechanical ventilators suitable for pediatric patients of all sizes must be available for each level I and level II PICU bed. Equipment for chest physiotherapy and suctioning, spirometers, and oxygen analyzers must always be available for every patient. Oxygen monitors (pulse oximeters and transcutaneous oxygen monitors) and CO_2 monitors (transcutaneous and end-tidal) are required; portable (transport) ventilators are desired.

AHA (American Heart Association)

2005

American Heart Association (AHA) Guidelines for Cardiopulmonary Resuscitation (CPR) and Emergency Cardiovascular Care (ECC) of Pediatric and Neonatal Patients: Neonatal Resuscitation Guidelines

PEDIATRICS Vol. 117 No. 5 May 2006, pp. e1029-e1038 (doi:10.1542/peds.2006-0349)

Endotracheal tube placement must be assessed visually during intubation and by confirmatory methods after intubation if the heart rate remains low and is not rising. Except for intubation to remove meconium, exhaled CO_2 detection is the recommended method of confirmation (Class IIa).

SCCM (The Society of Critical Care Medicine)

2004

American College of Critical Care Medicine of the Society of Critical Care Medicine

Guidelines and Levels of Care for Pediatric Intensive Care Units Guidelines and Levels of Care for Pediatric Intensive Care Units – 11/04/2004

Respiratory Equipment: Mechanical ventilators suitable for pediatric patients of all sizes must be available for each level l and level ll PICU bed. Equipment for chest physiotherapy and suctioning, spirometers, and oxygen analyzers must always be available for every patient. Oxygen monitors (pulse oximeters and transcutaneous oxygen monitors) and CO_2 monitors (transcutaneous and end -tidal) are required.

Bedside monitors: Bedside monitors in all PICUs must have the capability for continuously monitoring heart rate and rhythm, respiratory rate, temperature, 1 hemodynamic pressure, oxygen saturation, end –tidal CO_2, and arrhythmia detection.

2003

The measurement of exhaled carbon dioxide is the best signal of return of spontaneous circulation during CPR. Capnography is also a useful noninvasive index of the adequacy of pulmonary perfusion during closed-chest cardiac compression. Moreover, the quantitative measurement of end-tidal PCO_2 may have predictive value during CPR.

2003

Level I ICU: Services provided in unit: An ICU has the capability of providing monitoring and support of the critically ill patient. To do so, the ICU is prepared to provide the following: Capnography.

Pennsylvania Patient Safety Authority

2007

Patients with known or suspected OSA are at increased risk for life-threatening cardiopulmonary complications. The inherent problem of airway management during administration of general anesthesia and the large patient population with undiagnosed OSA increases the risk of developing complications postoperatively. OSA patients are susceptible to the respiratory depressant effects of sedatives, opioids, and inhaled anesthetics. Guidelines to consider when administering medications include: avoiding the use of sedatives and opioids, reducing doses and titrating slowly when administering sedatives and opioids, and administering local anesthesia whenever possible. Postoperative care is the pivotal time to implement interventions to reduce complications, especially within the first 24 hours. Postoperative risk reduction strategies focus on monitoring patients for an obstructed airway so that early detection may lead to prompt treatment.

Bibliography

Continuous, non-invasive arterial CO_2 estimation in spontaneously breathing patients after craniotomy. Wolter J, Dimache L, Nastasie A, Mohammed H, Pottecher T. The European Journal of Anaesthesiology. 2008; Vol. 25 (Suppl. 44).

Post operative opioid related respiratory depression in a major teaching hospital. Ginsberg B, Echenbacher L, Pharm D, Love A, Vanmatre R, Moon R. Anesthesiology. October 2007; Vol. 107, A182.

Patient-focused sedation and analgesia. Lain D. Chest. August 2008; Vol. 134, No. 2, 468-469.

Step Down

Pediatrics

The correlation and level of agreement between end-tidal and blood gas pCO_2 in children with respiratory distress: a retrospective analysis. Moses JM, Alexander JL, Agus MSD. BMC Pediatrics. March 2009; Vol. 9(20).

A novel method of distal end-tidal CO_2 capnography in intubated infants: Comparison with arterial CO_2 and with proximal mainstream end-tidal CO_2. Kugelman A, et al. Pediatrics. December 2008; Vol. 122, No. 6.

Utility of end-tidal CO_2 monitoring for assessment of tracheal intubation during neonatal resuscitation at birth. Hosono S, Kitamura T, Fujita H, Makimoto M, Minato T, Okada S, Takahashi H, Mugishima. 8th World Congress of Perinatal Medicine. September 2007.

$EtCO_2$ waveform monitoring provides a reliable and rapid assessment of ventilation and circulation during neonatal resuscitation. Nakamura T, Ito Y, Tsukamoto K, et al. World Congress of Anesthesiologists. 2004.

Accuracy of a new low-flow sidestream capnography technology in newborns: A pilot study. Hagerty JJ, et al. Journal of Perinatology. April/May 2002; Vol. 22, No. 3, 219-225.

Bibliography

End tidal CO_2 measurements with non-invasive ventilation. Nuccio P.F, Jackson M.R. Society for Technology in Anesthesia (STA). January 2009.

Smart Alarm Respiratory Analysis (SARA) used in capnography to reduce alarms during spontaneous breathing. Colman J, Cohen J, Lain D. Society for Technology in Anesthesia. 2008.

Analysis of environment and population during Microstream™ sidestream capnography utilization. Wales RA. Respiratory Care. November 2007; Vol. 52, No. 11.

Nasal airflow resistance, hyperventilation, and capnography. Adler S, Itzchak G, Giron B, Bubis Y, Lain D. European Respiratory Society. 2007.

Comparison of capnography derived respiratory rate alarm frequency using the SARA algorithm versus an established non-adaptive respiratory rate alarm management algorithm in bariatric surgical patients. Hockman S, Glembot T, Niebel K. American Association for Respiratory Care (AARC), December 2009.

General

Influence of sampling site on end tidal carbon dioxide levels ($PetCO_2$) during non-invasive positive pressure ventilation (NPPV). Taft A, Waugh J, Pippin G. American Association for Respiratory Care (AARC), December 2009.

Comparison of capnography derived respiratory rate alarm frequency using the SARA algorithm versus an established non-adaptive respiratory rate alarm management algorithm in bariatric surgical patients. Hockman S, Glembot T, Niebel K. American Association for Respiratory Care (AARC), December 2009.

Does medical education and training influence patient safety? Fitch-Bergenholtz K, Cummings A, Lain D. Anesthesiology. 2008.

Efficient ventilation utilizing noninvasive capnography. Waugh JB, Epps CA. AARC Times. March 2009.

The most important vital signs are not being measured. Ahrens T. Australian Critical Care. February 2008; Vol. 21, Issue 1, 3-5.

Recruitment maneuver improves respiratory function after off-pump coronary artery bypass grafting. Suborov E, Postnikova E, et al. European Journal of Anaesthesiology. 2008; Vol. 25 (Suppl. 44), 5AP3-5.

Capnometry in the spontaneously breathing patient. Srinivasa V, Kodali BS. Current Opinion in Anaesthesiology. December 2004; Vol. 17(6), 517-520.

Respiratory events during monitored anesthesia care in high-risk cardiac patients undergoing placement of implantable cardioverter-defibrillator. Chow JL, et al. Anesthesiology. 2004; Vol. 101, A1270.

Welch Allyn®

Advancing Frontline Care™

8500 SW Creekside Place, Beaverton, OR 97008-7107 USA
800.289.2500 technical support 800.289.2501

Welch Allyn Headquarters
4341 State Street Road, PO Box 220, Skaneateles Falls, NY 13153-0220 USA
800.535.6663

www.welchallyn.com

Oridion Capnography Inc.
160 Gould Street
Suite 205
Needham MA 02494
USA
Tel: (888) ORIDION
Fax: (781) 453-2722

Oridion Medical 1987 Ltd.
7 Hamarpe Street
97774
Jerusalem
Israel
Tel: +972 2 589 9158
Fax: +972 2 586 6680

www.oridion.com

Oridion®