

Volume 2 Number 3 June-July 2007

Respiratory Therapy™

The Journal of Pulmonary Technique

Special Report: Sleep
Also: Facility Reports
Resuscitation
Firefighters & HFCC

WELCOME TO THE FUTURE OF HUMIDIFICATION



Hydrate™



SMART HUMIDIFICATION HIGH FLOW OXYGEN THERAPY

PENDING FDA CLEARANCE

The **PARI Hydrate™** with **C-Force™ Technology**.

Assume no longer - know. 44 mg/L at up to 40 L/min.

Smart humidification is finally at your fingertips.

Contact PARI to receive more information on the future of humidification.



PARI RESPIRATORY EQUIPMENT, INC.

For more information call
1.800.FAST.NEB or visit us
online at www.PARIHYDRATE.com

**C-Force Technology utilizes Capillary Force Vaporizer, licensed by PARI from Vapore, Inc.*

NEBULIZERS

NASAL DRUG DELIVERY

HOLDING CHAMBERS

HUMIDIFICATION

COMPRESSORS

ML-33-001 REV 9/06

Patient safety from head to toe



New *OxiMax*[®] *NeoMax*[™] forehead sensors for neonates and infants



OxiMax[®] *N-600*[™] pulse oximeter stands up to difficult monitoring conditions



OxiMax[®] *N-85*[™] handheld capnograph/pulse oximeter with *Microstream*[®] capnography



OxiMax[®] *MAX-FAST*[®] forehead sensor for better performance in poor perfusion



Oxinet[®] *III* remote respiratory monitoring system for the general care floor



Leading patient monitors include *OxiMax* pulse oximetry options

OxiMax[®] pulse oximetry assures you of accurate, reliable performance even during low perfusion, patient motion and other forms of signal interference. Compatibility with the innovative line of *OxiMax* adhesive, reusable and specialty sensors further expands your options for monitoring from head to toe. From the worldwide leader in pulse oximetry: Nellcor.

 **NELLCOR**
Be Certain.

tyco
Healthcare

www.nellcor.com | 1-800-NELLCOR

© 2007 Nellcor Puritan Bennett LLC. All rights reserved. Microstream is a trademark of Oxidon Medical. All other trademarks belong to Tyco Healthcare Group LP or an affiliate.



Aeroneb[®] Solo

Experience the excellence of the Aeroneb[®] Pro nebulizer in single patient use format

The Aeroneb[®] Solo offers you the same renowned performance you have come to expect from Aeroneb[®] Pro in a lighter, compact, single patient use format

Increased convenience

- *Single patient use device*

Increased flexibility

- *Infant through adult for up to 28 days*

Dual functionality

- *Intermittent and continuous* nebulization*

Optimum aerosol characteristics

- *Incorporates OnQ[®] micropump aerosol generator*

For more information on the Aeroneb[®] Solo - Tel: (866) 423-7643 (US)
+353 91 502 550 (INTL) | Email: products@aerogen.nektar.com or visit www.aerogen.com

*Available in conjunction with the Aeroneb[®] Pro-X controller and for up to 7 days.


Aerogen



Is your suction safe?

Ours was designed with your patients in mind.



- **Patented Push-to-Set™** – Built-in feature that eliminates the need for you to occlude patient tubing to set accurate vacuum levels
- **Quick-To-Max** – Only 2 turns from 0 to full wall vacuum
- **Quietest** on the market
- **Stat Set-up** – Intermittent mode starts in the "ON" cycle – No Waiting





There's something in the air.

When respiratory professionals get wind of the new line of Smiths Medical PM, Inc. spirometers, we're confident they'll pronounce them positively inspired. The new spirometers use ATS approved turbine technology that is very sensitive in low flow situations and requires no routine calibration. These remarkable turbines are also disposable, which increases patient safety by reducing the risks of cross-contamination. Smiths Medical makes patient evaluation a breeze. For more information on our products, visit www.smiths-medical.com.

*Industry's
First
Disposable
Turbine*

Smiths Medical PM, Inc.

Patient Monitoring and Ventilation
N7 W22025 Johnson Drive, Waukesha, Wisconsin 53186 USA
Phone: 262-542-3100 Fax: 262-542-0718 Toll-Free USA: 800-558-2345
www.smiths-medical.com

Smiths Medical – a part of Smiths Group plc

Smiths Medical design mark is a trademark of Smiths Medical family of companies.
©2007 Smiths Medical family of companies. All rights reserved.

Are You Ready?

How can respiratory care providers prepare for SARS or a similar pandemic influenza outbreak? In the article "Pandemic influenza preparedness: an ethical framework to guide decision-making," (BMC Medical Ethics) Alison Thompson, et al, discuss the necessity of ethical strategies. Here's what the authors have to say:

Planning for the next pandemic influenza outbreak is underway in hospitals across the world. The global SARS experience has taught that ethical frameworks to guide decision-making may help to reduce collateral damage and increase trust and solidarity within and between health care organizations. Good pandemic planning requires reflection on values because science alone cannot tell us how to prepare for a public health crisis. The need for reflection on the ethical issues raised by the specter of a pandemic influenza outbreak is great. There is therefore a need to examine the ethical issues that arise from planning for a public health crisis of this magnitude. Who should get the limited supply of antivirals? Are healthcare workers duty-bound to care for the ill in a pandemic when they may have competing familial obligations? Who will be prioritized for scarce ventilated hospital beds? When should hospitals cancel elective surgeries or restrict hospital visitation?

Difficult decisions will have to be made about how, where and to whom resources should be allocated. Medical science provides valuable information to help make these decisions. However, science alone is insufficient. Now consider that resource allocation decisions are just one kind of decision decision-makers face in preparing for, and getting through an influenza pandemic. As a few scholars have begun to point out, pandemic planning needs to take ethical considerations seriously, and not allow the urgency of logistical and scientific needs to sideline a discussion of ethical considerations.

It is important to make presuppositions explicit, because, as the SARS experience in Toronto taught healthcare organizations, the costs of not addressing the ethical concerns are severe: loss of public trust, low hospital staff morale, confusion about roles and responsibilities, stigmatization of vulnerable communities, and misinformation. Another key insight from SARS that we overlook at our peril is that in times of crisis, fairness is more important, rather than less. Fairness considerations are both procedurally and substantively important: there is a need for fair decision-making processes, as well as equitable distributions of scarce human and material resources.

Take the example of triaging ventilated beds in an ICU. In theory, decision-makers rely on scientific evidence to determine how best to maximize benefit in the allocation of ventilated beds, but science cannot tell us whether or not the initial decision to maximize benefit is just.

Because the notion of maximizing benefit is derived from a reflection on values, ethical analysis is required to determine why a utilitarian approach to triage through maximization of benefit is preferable to the assignment of ventilated beds on a different basis, for example that of greatest need. Even if the utilitarian maximization of benefit is thought to be ethically sound, how to implement a system based on this criterion is not ethically straightforward, and requires ethical reflection about what counts as good stewardship, and about the moral obligation to demonstrate transparency, accountability, fairness and trustworthiness in the allocation of scarce resources.

The importance of ethics to pandemic planning is in the application of value judgments to science, especially as they are embedded in planning assumptions, and within the practice of medicine itself. For example, while ethics might have little to contribute to understanding the mechanism of influenza virus transmission, it can make a significant contribution to debates such as what levels of harm the



Respiratory Therapy™

The Journal of Pulmonary Technique

Vol. 2 No. 3

June-July 2007

Table of Contents

ARTICLES

- 25 Capnography at The Brooklyn Hospital Center
- 27 Castle Medical Center and ASV
- 29 Firefighters' Lungs and HFCC
- 35 Automatic Resuscitation
- 38 Infrared Trans-illumination

DEPARTMENTS

- 7 Editorial: Are You Ready?
- 12 News
- 15 Products
- 17 News Features: Helontix Symposium, Spontaneous Breathing, Tidal Volume, Intelligent Ventilation, Oxygenation
- 21 Executive Profile
- 22 Blood Gas Roundtable

SLEEP INTERNATIONAL

- 40 News
- 41 Products
- 42 Sleep Roundtable
- 54 Executive Profile
- 56 OSA and Depression
- 63 NEP and Apnea
- 71 Sleep Studies

Published six times each year by
Goldstein and Associates, Inc.

10940 Wilshire Blvd., Suite 600

Los Angeles, CA 90024 USA

Tel: 310-443-4109

Fax: 310-443-4110

E-mail: s.gold4@verizon.net

Website: www.respiratorytherapy.ca

Publisher
Steve Goldstein

Editor
Les Plesko

Senior Editor
Carol Brass

Assistant Editor
Laszlo Sandor

Design and Production Management
http://accugraphics.net

Circulation, Coverage, Advertising Rates: Complete details regarding circulation, coverage, advertising rates, space sizes, and similar information are available to prospective advertisers. Closing date is 45 days preceding date of issue.

Change of Address notices should be sent promptly to Circulation Department. Provide old mailing label as well as new address. Allow two months for change.

Editorial Contributions will be handled with reasonable care. However, publishers assume no responsibility for the safety of artwork, photographs or manuscripts. A hardcopy of all contributions may be mailed or faxed to our editorial offices. E-mail submissions will be accepted. Every precaution is taken to ensure accuracy, but the publishers cannot accept responsibility for the correctness or accuracy of information supplied herein or for any opinion expressed. Editorial closing date is the first day of the month preceding month of issue.

©2007 by Goldstein & Associates, Inc. All rights reserved. Reproduction in whole or in part without written permission is strictly prohibited.

Editorial Advisory Board

Russel A. Acevedo, MD, FAARC, FACP,
FCCM, FCCP
Medical Director,
Respiratory Care Department
Crouse Hospital, Syracuse, NY

Mohammed Al Ahmari, BSRT, MSc., RRT
Prince Sultan Military College
of Health Sciences
Al-Khobar, Saudi Arabia

Antonio Esquinas, MD, PhD, FCCP
Intensive Care Unit
Hospital Morales Meseguer
Murcia, Spain

Larry Conway, RRT
North Mississippi Medical Center
Tupelo, MS

Edwin Coombs, MA, RRT
Product Manager,
Critical Care Division
Maquet, Inc.
Bridgewater, NJ

Dr. Javier Fernandez
Director of Clinical Affairs & Education
Respiratory Division Latin America
Miami, FL

Gerardo N. Ferrero, PT
Clinical Specialist, Latin America
Buenos Aires, Argentina

Surinder K. Jindal, MD
Postgraduate Institute of Medical
Education & Research
Chandigarh, India

Rebecca A. Mabry
General Sleep Manager
Viasys Healthcare, Yorba Linda, CA

Paul Mathews, PhD, RRT, FCCM,
FCCP, FAARC
Associate Professor, Respiratory Care
University of Kansas Medical Center
Kansas City, KS

Hossein Razavi, MD, FCCP
Pulmonary, Critical Care &
Sleep Medicine
St. Helena, CA

Daniel D. Rowley, BS, RRT-NPS, RPFT
Surgical/Trauma/Burn ICU
University of Virginia Medical Center
Charlottesville, VA

J. Kyle Schwab, MD
Medical Director
Louisiana Sleep Foundation
Baton Rouge, LA

public are prepared to accept, how the burdens of negative outcomes should be distributed across the population and whether or not more resources should be invested.

One of the key lessons from the Toronto SARS experience was that healthcare institutions and their staff could benefit from the development of ethical frameworks for decision-making. Not surprisingly, the literature on clinical ethics has little to say about disaster preparedness and how to make decisions about such things as triage under extraordinary circumstances. The ethics literature on bioterrorism and battle-field triage can inform thinking and call attention to important issues such as the duty to care, reciprocity, equity and good stewardship. The ethical framework should be intended to inform decision-making, not replace it. It is intended to encourage reflection on important values, discussion and review of ethical concerns arising from a public health crisis. It is intended also as a means to improve accountability for decision-making and may require revision as feedback and circumstances require.

In planning for and throughout a pandemic influenza crisis, difficult decisions will be made that are fraught with ethical challenges. Stakeholders will be more able to accept difficult decisions during a pandemic influenza crisis if the decision-making process has, and is perceived to have, ethical legitimacy.

Factors that need to be decided on the basis of ethical requirements are: a) targeting and prioritizing populations for vaccines and antivirals; b) Intensive Care Unit and hospital bed assignment; c) duty to care; d) human resources allocation and staffing; e) visiting restrictions; and f) communications and how

reviews of decisions will be handled. For 10 specific ethical values, see the table on the next page.

Some may argue that the values in the framework are too stringent or impractical to implement under crisis conditions. Certainly, crisis conditions may place constraints on the extent to which each principle can be acted upon. However, efforts should be made to put them into action to the fullest extent possible under the circumstances.

The above is excerpted and edited from the article "Pandemic influenza preparedness: an ethical framework to guide decision-making," BMC Medical Ethics, © 2006 Thompson et al; licensee BioMed Central Ltd. The paper is an Open Access article distributed under the terms of the Creative Commons Attribution License. For the full article please go to the website BioMed Central, and type in the name of the article. A look at the Toronto SARS experience can be found in this journal, Vol 1 No 3, page 41.

Ethical values to guide decision-making (Listed in alphabetical order)

Value	Description	Example
Duty to Provide Care	<p>The duty to provide care and to respond to suffering is inherent to all health care professionals' codes of ethics. In an influenza pandemic, demands on health care providers and the institutions in which they work will overwhelm resources. Health care providers will have to weigh demands from their professional role with other competing obligations to their own health, to family and friends. Health care workers will face significant challenges related to resource allocation, scope of practice, professional liability, and workplace conditions.</p> <p><i>Decision makers should:</i></p> <ul style="list-style-type: none"> • Work collaboratively with stakeholders and professional colleges in advance of an influenza pandemic to establish practice guidelines • Work collaboratively to develop fair and accountable processes to resolve disputes • Provide supports to ease this moral burden of those with the duty to care • Develop means through which institutions will handle appeals or complaints, especially with regards to work exemptions, or the vaccination/prophylaxis of staff 	<p>Health care workers who are at increased risk because they are caring for patients with influenza must weigh familial obligations, and obligations to self with their professional duty to care. In addition, they may also have to comply with vaccination or antiviral regimens for prophylaxis which may conflict with their individual liberty.</p>
Equity	<p>The principle of equity holds that, all things being equal, all patients have an equal claim to receive needed health care. During influenza pandemic, however, tough decisions will need to be made about which health services to maintain and which to defer because of extraordinary circumstances. Measures taken to contain the spread of a deadly disease will inevitably cause considerable collateral damage. In an influenza pandemic, this will extend beyond the cessation of elective surgeries and may limit the provision of emergent or necessary services.</p> <p><i>Decision-makers must strive to:</i></p> <ul style="list-style-type: none"> • Preserve as much equity as possible between the interests of patients [afflicted with the influenza] and those who need urgent treatment for other diseases • Ensure procedural fairness in decision-making 	<p>In allocating scarce resources, the value of equity could guide in developing fair criteria for allocation while consideration is given also to compensation for those who will not meet inclusion criteria yet are entitled to receive care.</p>
Individual Liberty	<p>Individual liberty is a value enshrined in health care practice under the principle of respect for autonomy. Under usual circumstances, health care providers balance respect for individual autonomy with a duty to protect individual patients from harm. In a public health crisis, however, restrictions to individual liberty may be necessary to protect the public from serious harm. Patients, staff, and members of the public may all be affected by such restrictions.</p> <p><i>Restrictions to individual liberty should:</i></p> <ul style="list-style-type: none"> • Be proportional to the risk of public harm • Be necessary and relevant to protecting the public good • Employ the least restrictive means necessary to achieve public health goals • Be applied without discrimination 	<p>Social distancing strategies that employ visitor restrictions in hospitals must be necessary for the protection of the public and must be proportionate to the threat being allayed.</p>
Privacy	<p>Individuals have a right to privacy in health care. In a public health crisis, it may be necessary to override this right to protect the public from serious harm. A proportionate response to the need for private information requires that it be released only if there are no less intrusive means to protect public health.</p> <p><i>Decision makers should:</i></p> <ul style="list-style-type: none"> • Disclose only private information that is relevant to achieve legitimate and necessary public health goals • Release private information only if there are no less intrusive means to protect public health • Determine whether the good that is intended is significant enough to justify the potential harm that can come from suspending privacy rights, (e.g. the harm from stigmatization of individuals or particular communities) • Provide public education to correct misconceptions about disease transmission and to offset misattribution of blame to particular communities 	<p>The need to conduct contact tracing of possibly infected people might require that particular groups or even individuals are identified publicly. The need to do so must be weighed against the potential harm of exposing communities and individuals to stigmatization.</p>
Proportionality	<p>Proportionality requires that restrictions to individual liberty and measures taken to protect the public from harm should not exceed what is necessary to address the actual level of risk to, or critical need of, the community.</p> <p><i>Decision makers should:</i></p> <ul style="list-style-type: none"> • Use least restrictive or coercive measures in limiting or restricting liberties or entitlements • Use more coercive measures only in circumstances where less restrictive measures have failed to achieve appropriate public health ends. 	<p>The decision to close an emergency room must consider if the potential harm in keeping the emergency room open is significant enough to warrant its closure.</p>
Protection of the Public from Harm	<p>A foundational principle of public health ethics is the obligation to protect the public from serious harm. This principle requires that citizens comply with imposed restrictions in order to ensure public wellbeing or safety. To protect the public from harm, hospitals may be required to restrict public access to service areas (e.g. restricted visiting hours), to limit availability of some services (e.g. elective surgeries), or to impose infectious control practices (e.g. masks or quarantine).</p> <p><i>When making decisions designed to protect the public from harm, decision makers should:</i></p> <ul style="list-style-type: none"> • Weigh the medical and moral imperative for compliance • Ensure stakeholders are made aware of the medical and moral reasons for public health measures • Ensure stakeholders are aware of the benefits of compliance & the consequences of non-compliance • Establish mechanisms to review these decisions as the public health situation changes and to address stakeholders concerns or complaints 	<p>When making the decision to quarantine individuals, protection of the public from harm must be weighed against individual liberty. Note that while the ethical value of individual liberty is often in tension with the protection of the public from harm, it is also in individuals' interests to minimize harm to others.</p>
Reciprocity	<p>Reciprocity requires that society supports those who face a disproportionate burden in protecting the public good and takes steps to minimise their impact as far as possible. In an influenza pandemic, measures to protect the public good are likely to impose a disproportionate burden on health care workers, patients, and their families. Health care workers may face expanded duties, increased workplace risks, physical and emotional stress, isolation from peers and family, and in some cases, infection leading to hospitalization or even death. Similarly, quarantined individuals or families of ill patients may experience significant social, economic, and emotional burdens.</p> <p><i>Decision-makers and institutions are responsible for:</i></p> <ul style="list-style-type: none"> • Easing the burdens of health care workers, patients, and patient's families in their hospitals and in coordination with other health care organizations • Ensuring the safety of their workers, especially when redeploying staff in areas beyond the usual scope of practice 	<p>The provision of antiviral medication and/or vaccination to hospital staff for prophylaxis is one way hospitals can ensure the safety of their workers who may be exposed to greater than usual risks in discharging their duty to care.</p>
Solidarity	<p>SARS heightened the global awareness of the interdependence of health systems and the need for solidarity across systemic and institutional boundaries in stemming a serious contagious disease. An influenza pandemic will not only require global solidarity, it will require a vision of solidarity within and between health care institutions.</p> <p><i>Solidarity requires:</i></p> <ul style="list-style-type: none"> • Good, open and honest communication • Open collaboration, in a spirit of common purpose, within and between health care institutions • Sharing public health information • Coordinating health care delivery, transfer of patients, and deployment of human and material resources 	<p>Territoriality between hospital departments and between health care institutions needs to be overcome with good communication and sense of common purpose in order to provide equitable care across jurisdictions</p>
Stewardship	<p>In our society, both institutions and individuals will be entrusted with governance over scarce resources, such as vaccines, antivirals, ventilators, hospital beds and even health care workers. During a pandemic influenza outbreak, difficult decisions about how to allocate material and human resources will have to be made, and there will be collateral damage as a result of these allocation decisions. Those entrusted with governance roles should be guided by the notion of stewardship. Inherent in stewardship are the notions of trust, ethical behaviour, and good decision-making.</p> <p><i>Decision makers have a responsibility to:</i></p> <ul style="list-style-type: none"> • Avoid and/or reduce collateral damage that may result from resource allocation decisions • Maximize benefits when allocating resources • Protect and develop resources where possible • Consider good outcomes (i.e. benefits to the public good) and equity (i.e., fair distribution of benefits & burdens) 	<p>A hospital's decision to stock-pile antiviral medication must consider whether this is an effective way of protecting staff from infection, where the money for stockpiling will come from, and whether that money could be put to better use elsewhere.</p>
Trust	<p>Trust is an essential component in the relationships between clinician and patient, between staff and the organization, between the public and health care providers, and between organizations within a health system. In a public health crisis, stakeholders may perceive public health measures as a betrayal of trust (e.g. when access to needed care is denied) or as abandonment at a time of greatest need. Decision-makers will be confronted with the challenge of maintaining stakeholders' trust while at the same time stemming an influenza pandemic through various control measures. It takes time to build trust.</p> <p><i>Decision-makers should:</i></p> <ul style="list-style-type: none"> • Take steps to build trust with stakeholders before the crisis hits not while it is in full swing • Ensure decision making processes are ethical and transparent to those affected stakeholders 	<p>Early engagement with stakeholders may go some distance to justify stakeholder confidence in decision-makers' trustworthiness. In part, the value of trust is respected and promoted by following the ethical processes outlined above.</p>

Helping hospitals through the reimbursement maze



So far, 115 hospitals across the nation have increased reimbursement for INOmax® (nitric oxide) for inhalation. Is your hospital one of them?

Our team can help you identify the information you need to seek and obtain appropriate payment. To learn more, please contact INO Therapeutics and the INOtherapy Reimbursement Service at 1-877-KNOW-INO (1-877-566-9466) or visit www.inotherapeutics.com.

□ June-July 2007

OBSERVATIONS ON REIMBURSEMENT

Richard M. Ford, BS, RRT, FAARC

The author is Director of Respiratory Services, University of San Diego Medical Center, San Diego, CA. Dr. Ford's comment is in response to the article Inpatient Drug Reimbursement on page 39 of the previous issue.

As indicated from our billing experts in INO therapeutics, in the absence of a CPT code specific to bill nitric oxide, Respiratory Managers must take extra measures and efforts to explore every opportunity for payment. It is no easy task to get CMS to approve a new CPT code; thus direct reimbursement remains limited to incorporation of such cost in contracts as well as mechanisms in the DRG system for outliers and stop-loss situations. In order to qualify for these limited reimbursement opportunities it is important that managers continue to document and track nitric oxide use as they would for any billable service. The utilization and direct cost of nitric oxide remain essential to track. It is also important to remember that protocols which specify the indications for initiation of NO as well as titration to discontinuance become more important to have in place. Not only to ensure care is appropriate, but to minimize cost in an environment in which reimbursement is provided under the daily per diem or DRG capitated-type programs that currently exist. Measures to limit utilization to only cases of clearly defined medical necessity will reduce the overall direct expense of care and therefore, the potential profitability of services.

WHEN THE SMOKE CLEARS

Treatment of health problems experienced by the 43,000 individuals exposed to toxic dust and smoke during the World Trade Center collapse on Sept. 11, 2001, has cost the U.S. health care system \$393 million annually since 2001, according to a report issued on Tuesday by a panel established by New York City Mayor Michael Bloomberg in 2006, the New York Times reports. First responders and other individuals exposed to the dust and smoke have experienced respiratory, digestive and mental health problems. Individuals exposed to the dust and smoke also could experience long-term health problems, such as cancer and pulmonary fibrosis, the report said. Bloomberg has asked the federal government for \$150 million annually to cover the cost of programs to screen, treat and monitor the health of individuals exposed to the dust and smoke. In addition to the cost of health problems, the report said that first responders have filed at least 6,000 federal lawsuits over allegations that New York City and city contractors were negligent in efforts to monitor air quality, with thousands of additional lawsuits expected. The report recommended that New York City place funds from the WTC Captive Insurance, established by Congress in 2004 to cover the cost of liability claims, in a compensation program for individuals exposed to the dust and smoke who have experienced health problems.

DOPED

Researchers at the Department of Academic Medicine at the University of Hull and Castle Hill Hospital in East Yorkshire, UK enrolled 27 patients with intractable cough in an eight-week, randomized, double-blind, placebo-controlled study to test the use of slow-release morphine sulfate versus a placebo on their cough. Each phase lasted four weeks. Although opiates have been long advocated for the suppression of cough, there are few trial data to support this recommendation. In fact, prior to this research, the use of opiates in intractable chronic cough had never been studied. The investigators found a rapid and highly significant reduction by 40% in daily cough scores was noted by patients on slow-release morphine sulfate. Patients responded quickly to treatment starting at five milligrams twice daily. The researchers found patients benefited the most by day five of treatment, and that this response was sustained through the remainder of the four-week period. The authors noted that the rapid response to morphine was in contrast to the absence of any effect of placebo. All participants had endured a chronic, persistent cough for more than three months. Their average age was 55. During each four-week interval, patients made three visits to a clinical trial center, where they filled out a quality-of-life questionnaire on the impact of chronic cough on activities of daily living. A spirometric lung test was performed at the first visit, and lung function was measured on each subsequent visit. According to the authors, one-third of the participants increased their dose of morphine sulfate from 5 mg to 10 mg twice daily during the first month; 11% did so in the second month; and a further 22% joined them in the third month. By the end of the study, two-thirds of the patients had increased their dose to 10 milligrams. The most common side effects were constipation and drowsiness. Reported in Medical News Today.

SQUEAKY SOLUTION

Researchers at the University of Alberta in Edmonton, Canada have discovered that combining helium with 40% oxygen allowed patients with COPD to increase their exercise capacity by an average of 245%. This was the first study to demonstrate that helium-hyperoxia improves the exercise tolerance of COPD patients to a greater extent than oxygen alone, which is currently used for treating patients with this disorder. The results of the study were published recently in the American Journal of Respiratory Critical Care Medicine and reported by Medical News Today. In the study 10 clinically stable men with moderate to severe COPD were each given four different mixes of gases including room air, while they exercised. During each test they were monitored for exercise time, breathing capacity, work of breathing and symptoms of exertion. The best results were achieved with a mix of 40% oxygen and 60% helium. The helium-hyperoxia mixture improved the exercise tolerance of the patients by 245%, compared with other approaches which yielded results of 21% to 80%.

TREATMENT VARIES

New research suggests that different treatments may be needed for chronic asthma, depending on whether it results from allergies or lung infections. Previous studies have shown that certain lung infections such as *Mycoplasma pneumoniae* can linger on and contribute to a person later experiencing symptoms of asthma.

Researchers have now identified a particular gene that influences how severe a *M. pneumoniae* infection may be, which in turn suggests that a different strategy might be needed for

GEM Premier 3000 with IQM™

The Clear Path to Improved Patient Care

GEM is a registered trademark, and IQM, GEMweb, CFL, PO₂, and Premier are trademarks of Instrumentation Laboratory. © 2015 Instrumentation Laboratory. "with the optional GEM CFL CO-Osmetry module," "with the optional GEM CFL CO-Osmetry module," "with the optional GEM CFL CO-Osmetry module."

- ▶ pH, PCO₂, PO₂
- ▶ Ca²⁺, Na⁺, K⁺
- ▶ Glucose, Lactate
- ▶ Hct
- ▶ CO-Ox²
- ▶ PT, Cit PT, APTT, ACT, ACT-LR™

Your patients deserve the best care possible. The GEM Premier 3000 gives you a clear path to make that possible. Thanks to its Intelligent Quality Management (IQM)—a real-time, automated, continuous quality assurance system—only the GEM Premier 3000 helps guarantee the quality of every test result and allows you to spend more time where you're needed most. So it's no surprise that IL is the #1 choice in the best hospitals¹ across the United States—the Standard of Care. **Choose the right path. Choose the GEM Premier 3000.** Contact IL at 1-800-955-9525 or visit www.ilus.com.



Innovation • Leadership • Commitment

¹Data on file, IL and US News & World Report, July 2003.



treating asthma resulting from this and similar lung infections rather than allergies. Researchers have been using mice to study how certain pneumonia bacteria contribute to chronic asthma and, in this latest study, identified how a particular gene may contribute to more severe lung infection. The research appears in the January edition of *Infection and Immunity*. To investigate the mechanism by which *M. pneumoniae* causes lung disease and respiratory difficulties, UT Southwestern researchers inoculated two different types of mice with this bacterium. The study contrasted the reaction of one normal group of mice with another group lacking a particular gene called IL-12, which is involved in immune response. The mice engineered without the gene showed significantly less lung inflammation than the mice that naturally had the gene, with some indicators showing seven times less inflammation. Because the *M. pneumoniae* bacterium is difficult to kill and often remains in the lungs even after antibiotic treatment and the symptoms fade, the importance of finding better treatments was deemed to be vital.

DON'T DO IT

A new study suggests that patients with COPD who are undergoing bronchoscopy, should not be premedicated with bronchodilators. Researchers from the University Hospital Basel, Switzerland, gathered 120 patients with COPD and randomized them into three groups to receive salbutamol, placebo, or nothing prior to bronchoscopy. Pulmonary function tests were performed on all patients both before and after the procedure. Results showed that in all groups, FEV1 decreased significantly postbronchoscopy and that the percentage of patients experiencing postbronchoscopic deterioration was similar. Researchers conclude that patients with COPD do not need to be premedicated with short-acting β -agonists prior to bronchoscopy. This study appears in the March issue of *CHEST*, the peer-reviewed journal of the American College of Chest Physicians. The study revealed that ICS may not be as effective in treating the disease as previously thought. In a pooled study, researchers from the University of Minnesota and Oregon Health and Science University, along with researchers from Canada, United Kingdom, and Europe analyzed data from nearly 4,000 patients with COPD, who were randomized and treated with either ICS or a placebo. Results showed that ICS use was associated with a significant FEV1 increase within the first 6 months of use and that they were more effective in improving lung function in ex-smokers than in current smokers. However, researchers found that after 6 months, there was no significant difference between placebo and ICS in modifying FEV1 decline. This study appears in the March issue of *CHEST*. The study revealed that in vivo expression of SPDEF in mouse lung epithelial cells is increased by IL-13 and exposure to dust mite allergens. This increased SPDEF expression was associated with an increase in the number of goblet cells. In vitro, SPDEF was shown to interact with the protein TFF-1 and to increase the expression of genes encoding proteins that caused the epithelial cells to become goblet cells and to produce mucous proteins. This study therefore indicates that SPDEF has a crucial role in endowing the lung with the characteristics of chronic lung disease.

NO HARM DONE

Preemies between 28 and 32 weeks are not harmed by a treatment no longer used to help their lungs mature before birth, according to findings of a study in a recent issue of *Pediatrics*. Even though previous observational studies

suggested that repeated courses of steroids in the womb may result in brain damage, this study shows that the babies' brains are virtually unaffected. Before concerns arose in 2000 about safety of multiple courses of steroids, many mothers in on-and-off preterm labor received several rounds before delivering. Now, when mothers go into preterm labor, obstetricians will often administer only a single course of steroids to help strengthen the baby's lungs upon birth. But if the birth is successfully held off for more than seven days, the mother does not receive another course of medication and the baby's lungs may not be protected. Previous studies showed neurological complications from multiple courses of dexamethasone, a steroid prepared with sulfur. However, clinicians do not commonly use that steroid anymore and have largely switched to sulfur-free steroids, such as betamethasone. This study was based on infants who received betamethasone prior to birth, and they did not show the same adverse effects as previous studies. The study, which was performed by analyzing data collected in the neonatal intensive care unit at Golisano Children's Hospital at Strong between 1996 and 1998, included 174 babies who were born at 28 to 32 weeks. Their brain functioning was measured by ABR. There were no significant differences in the brain's responses to the testing between the 50 babies who received one course of steroids and the 29 who received two or more courses, even when controlled for gestational age, birth weight, race and exposure to illegal drugs. There were also no significant differences between the 51 infants who received no steroids and those who did. The only medical difference between those infants who received one course and those who received more was that the ones who received more were less likely to need mechanical ventilation the day they were born.

MICE & MEN & WOMEN

In a study that appears in the March issue of the *Journal of Clinical Investigation*, researchers from the Harvard School of Public Health, Boston, identified a new mechanism by which mice are protected against inhaled oxidants. Lester Kobzik and colleagues observed that alveolar macrophages of mice resistant to lung damage caused by the oxidant ozone expressed more of the protein MARCO than the alveolar macrophages of mice susceptible to ozone-induced lung damage. Consistent with a role for MARCO in protection from oxidant-induced lung damage, mice lacking MARCO showed more lung damage when exposed to either ozone or another oxidant than mice expressing normal amounts of MARCO. MARCO provided protection by enabling alveolar macrophages to take up lipids in the lung modified by the oxidant that would initiate an inflammatory reaction if not removed. A similar role in the removal of lipids in the lung modified by these oxidants was identified for another protein related to MARCO, SR-AI/II. As discussed in an accompanying commentary, it is now important to determine whether similar functions can be ascribed to these and other related proteins (all of which are known as scavenger receptors) in humans because of the extensive morbidity associated with lung diseases such as asthma and COPD.

ANYWHERE, ANYTIME

Hypoxia can occur throughout the body (eg, at high altitude) or within a specific organ or tissue of the body (eg, due to blockage of a blood vessel). In many instances, inflammation is the response of the body to hypoxia and this often causes many of the problems that arise from hypoxia. However, the body can be protected from some of the more severe effects of hypoxia

by hypoxic preconditioning (HPC), that is, exposure to moderately decreased amounts of oxygen. In a study in the *Journal of Clinical Investigation*, researchers from Children's Hospital Boston, show that if mice undergo HPC their lungs exhibit an attenuated inflammatory response to severe hypoxia compared with mice that received no HPC. In particular, the expression of genes regulated by the pro-inflammatory regulator NF-kappa-B was decreased. This decrease in NF-kappa-B activation was mediated by adenosine produced by cells exposed to HPC. Further analysis showed that adenosine inactivated a protein (cullin-1) that is required for NF-kappa-B activation by a process known as deneddylation. This study identifies an anti-inflammatory mechanism activated in the lungs by HPC and mediated by adenosine. Future studies will investigate whether the same mechanism protects other tissues from the severe effects of hypoxia.

KEEP IT CLEAN (AND DRY)

Damp and mould in the home can contribute to the onset of child asthma, according to a Finnish study. Up to one in five cases (20%) of child asthma may be caused this way, according to the National Public Health Institute's Department of Environmental Health in Kuopio. The researchers found that the risk increases with the severity of the damp, particularly where there is visible mould in the bedrooms. The study covered 121 newly diagnosed asthmatics aged from one to seven, and 241 control subjects. Doctors will now need to keep this factor in mind when seeking the cause of a child's asthma. Where there are doubts, it may be useful to have the home examined by an expert. Many studies have shown a link between excess damp in buildings and various respiratory symptoms, including wheezing, coughing and asthma. However, while its role in exacerbating existing asthma was recognized, it had not yet been established that it could cause the onset of the condition. Researchers recruited to the study, over a four-year period, all children aged from one to seven who were newly diagnosed with asthma. The resulting subject group of 121 asthmatic children was compared to 241 non-asthmatic peers. All of them had lived at least two years, or three-quarters of their life, at their current home. In addition to a detailed interview and a specific IgE test to screen for allergic antecedents, both the asthmatics and the control subjects were visited at home by experienced civil engineers, who inspected all the rooms according to a strictly established procedure. The experts assessed, for each house, the level of damp and the presence of any mould. They looked particularly at leaks, condensation marks, damp stains, changes in the colour of the building materials, or peeling on the surface of walls. Signs of serious damp or visible mould were observed two to three times more often in homes inhabited by asthmatic children than in those of their healthy peers. However, damp and mould infestation in non-family parts of the house, such as lofts and cellars, appears to have little impact on respiratory health. In analysing this causal link between damp and asthma, the authors also broke down the data by age and by whether or not children had allergic antecedents. The researchers concluded that dampness in the home did more than merely exacerbate existing asthma: it can contribute to the onset of persistent asthma. For more see the *European Respiratory Journal*.

YET ANOTHER WORRY

Newborns with respiratory distress should be evaluated for primary ciliary dyskinesia, a rare genetic disease that has features similar to cystic fibrosis, said Thomas Ferkol, MD, from

Washington University School of Medicine in St Louis, as reported in *Medical News Today*. He reported finding that about 80% of patients with primary ciliary dyskinesia (PCD) have a history of newborn respiratory distress. Research by Ferkol at the Division of Pediatric Allergy and Pulmonary Medicine at Washington University School of Medicine and St. Louis Children's Hospital, found that neonatal respiratory distress was a common clinical symptom of PCD, a chronic airway disease that affects about 1 in 15,000 children. Their findings appeared in *Seminars in Perinatology*. Also known as immotile cilia syndrome, ciliary aplasia or Kartagener Syndrome, PCD causes persistent wheezing and cough in children and is associated with recurrent or persistent sinus and ear infections. Half of patients with PCD have reversed internal organs, called situs inversus, and males are usually infertile. In PCD patients, the cilia, tiny hairs that move mucus, bacteria and particulates out of the respiratory tract, including the lungs, middle ear and paranasal sinuses, have abnormal or no motion. As a result, the airways become obstructed and infected, which incites a destructive inflammatory process in those organs. Cilia are also present in the female reproductive system, central nervous system and gut. Researchers said that physicians often failed to consider PCD, in part because we don't have a great diagnostic test for the disease. Several clinical features of PCD mirror those found in the more-common cystic fibrosis, including chronic sinus and lung disease as well as male infertility. However, chronic ear disease and neonatal respiratory distress are relatively uncommon in cystic fibrosis and should prompt the caregiver to consider PCD, according to the research. Because definitive testing is not always readily available, patients with PCD are often diagnosed late. In addition, treatment of PCD in the community is highly variable, largely because the necessary clinical studies have not been performed.

PRODUCTS

GOING HOME

As it begins to mark its 100th anniversary in the ventilation industry, Draeger Medical announces the launch of its newest ventilator, the Carinahome, into the US market. Carinahome's design enables caregivers to support patients' ongoing conditions away from clinical settings. Providing both invasive and non-invasive ventilation, the new ventilator enables far greater independence and choice of care settings for many patients with respiratory disorders. The Carinahome, with its unique user interface concept means that while a full-access interface is available, showing both pressure and flow curves, a dedicated patient-friendly screen enables patients to adjust pre-determined settings according to their personal needs. In addition, the Carinahome's AutoSlope and SyncPlus attributes further support the patient by making triggering and breathing comfortable and gentle. Contact draeger.com.

NEW MAN

Viasys announced that Ed Pulwer, Viasys Healthcare Inc COO, has assumed the additional role of Group President, Viasys NeuroCare. Randy H. Thurman, Chairman, President and Chief Executive Officer, commented, "Ed has established an extraordinary track record in his 30 years in the medical technology industry. Ed previously led the respiratory diagnostics and critical care businesses within Viasys. Following the successful implementation of his strategy, both of these businesses are now considered to be global technology and

market leaders in their respective healthcare segments. Ed has proven himself to be an outstanding leader who delivers on his commitments in product development, sales and marketing and operational and financial performance. His early career included key leadership roles in sales and marketing. Most importantly, he has demonstrated his ability to build winning teams, integrate the best of all ideas and empower people of all levels.”

CASTING A WIDER WEB

Draeger Medical introduces a comprehensive, web-based information management solution that integrates vital OR, PACU and ICU patient information from medical devices and systems across the Acute Point of Care (APOC). Innovian Solution Suite streamlines access to patient information by providing one platform for the critical and perioperative care environments. It strengthens Draeger Medical’s suite of information management solutions, which also includes a distributed, client-based anesthesia information management solution for the OR. The new web-based components of the suite include solutions for the perioperative and critical care environments. In the perioperative environment, Draeger Medical’s OR/Anesthesia information management system covers scheduling, pre-op, holding, intra-op and PACU. For critical care there is an ICU documentation system that provides full electronic patient charting, flowsheet, scoring and printed reports. Working together, these solutions continually capture vital patient information from perioperative and critical care medical devices and clinical information systems. That data is integrated into one, easy-to-navigate interface for direct access by clinicians. A more accurate patient record is possible when patient data is automatically placed into the record. With electronic charting clinicians can spend less time writing and have more time for patient care. Draeger Medical’s web-based information management solutions support Pick and Go technology. This enables information collected by Infinity monitors during patient transfer to be automatically backfilled into the database. Moreover, because it is built on open standards, it fully supports HL7 interfaces to the hospital information system. Contact draeger.com.

GET SMART

Draeger Medical, Inc announced FDA 510k clearance for its new Infinity TeleSmart system featuring a compact device capable of monitoring ECG and SpO₂. Infinity TeleSmart provides the performance of a full-size patient monitor, packaged in a compact patient-worn telemetry device for adult and pediatric patients. Built-in ACE (Arrhythmia Classification Expert) and pacer detection algorithms enhance ECG processing and reduce false alarms. Infinity TeleSmart allows for viewing patient information at the patient’s side. Unlike traditional telemetry, Infinity TeleSmart has a color display that shows the patient’s ECG for all monitored leads, heart rate, SpO₂, and electrode status. It also shows patient demographics to help confirm the patient’s identification before giving medications, taking blood samples, or performing treatments. The TeleSmart has built-in alarming and alarm controls, which provides alarm alerts both at the patient’s side and the central monitoring station. The color display helps the clinician to assess the alarms and respond accordingly. The Infinity TeleSmart also has a built-in rechargeable battery. The battery can be recharged via a bedside charger or at a multi-device charger at the central monitoring station. Because Infinity TeleSmart has a built-in display and alarms, it enables the clinical staff to be alerted to patient conditions without having to use additional devices. Based on

the industry-standard 802.11b WiFi technology, Infinity TeleSmart provides continuous standalone monitoring – even if the patient moves out of the hospital’s wireless network coverage area. The TeleSmart can be used with the OneNet shared network and hospitals can use their industry-standard 802.11b (WiFi) access points for both telemetry and patient monitoring. Wireless data exchange and signal integrity is facilitated with bidirectional communication between Infinity TeleSmart and the Infinity CentralStation.

IN THE BLOOD

RNA Medical, division of Bionostics, Inc., Devens, MA, announces CVC 123, Calibration Verification Controls for use with blood gas, electrolyte, and metabolite analyzers, is now assayed for IL GEM Premier 3000, Bayer 400 Series, and Radiometer ABL800 Series analyzers. CVC 123 is used to confirm the calibration and linearity of blood gas systems measuring pH, pCO₂, pO₂, sodium, potassium, chloride, ionized calcium, ionized magnesium, glucose, and lactate. Provided in 5 levels, it is packaged in kits containing 4 ampuls of each level. In addition to US availability, CVC 123 is distributed in Canada through Thermo Fisher Scientific. Contact (800) 533-6162 RNAMedical.com.

TAKING THE PULSE

Nonin Medical, Inc announced today that it has entered into an agreement with MedAssets Supply Chain Systems, a leading US healthcare group purchasing organization (GPO), to make its comprehensive line of pulse oximeters and sensors, including the only wireless oximeter based on Bluetooth technology, available to MedAssets customers. Under the multi-year agreement with Nonin, MedAssets customers, numbering more than 1,500 acute care hospitals and 25,000 alternate-site facilities nationwide, will have access to these pulse oximeters and sensors. Minneapolis-based Nonin Medical, Inc designs, manufactures and distributes a broad spectrum of physiological monitoring devices, currently used by health and medical professionals in more than 125 countries. The company draws upon its industry-leading capabilities in signal processing and sensor design to develop innovative pulse oximeters, sensors, accessories and software with features not available in competing products. MedAssets partners with healthcare providers to improve operating margins and cash flow while supporting quality of care goals. MedAssets implements integrated solutions to address the greatest opportunities for financial and process improvement and drives performance in revenue cycle, supply chain and clinical service line management. MedAssets is a business partner to more than 2,400 hospitals and 25,000 non-acute care healthcare providers. For more information, go to medassets.com.

UPGRADED

A software upgrade (Version 5) to the Nova Biomedical Stat Profile Critical Care Xpress analyzer provides the reporting of estimated Glomerular Filtration Rate (eGFR) with every serum creatinine measurement. eGFR is a calculated test that considers the effects of age, sex, and body weight on creatinine generation, thereby adjusting serum creatinine values to more accurately reflect creatinine clearance. An eGFR calculated from serum creatinine is a practical way to detect, evaluate, and manage people with chronic kidney disease (CKD), especially people with risk factors for CKD—diabetes, hypertension, cardiovascular disease, or family history of kidney disease—in whom CKD might otherwise go undetected and untreated. Stat

Profile Critical Care Xpress offers a comprehensive 20-test critical care profile including blood gases, electrolytes, chemistry, hematology, and co-oximetry. Nova is among the few critical care companies to offer serum creatinine as part of its analyzer test profile and is the only critical care company to provide the eGFR calculation. Version 5 software enables Stat Profile Critical Care Xpress analyzers to be configured for all of the currently accepted eGFR equations, including Cockcroft-Gault, MDRD, and IDMS-Traceable calculations for adults, and Schwartz and Counahan-Barrett calculations for children. Contact novabio.com.

ADAPTIVE

Respironics, Inc announced that it has formed an agreement with The State University of New York (SUNY) and New York University School of Medicine (NYU) to utilize the I-neb Adaptive Aerosol Delivery (AAD) System for clinical evaluation of aerosolized Interferon Gamma for the treatment of Idiopathic Pulmonary Fibrosis (IPF). The clinical trial will take place over a two-year time period. The I-neb device uses Respironics' AAD technology which is an intelligent inhalation technology that continually monitors and automatically adapts to an individual patient's breathing pattern to deliver a precise medication dose during the patient's inhalation phase. The result is precise, reproducible dosing of medication to each patient, regardless of his/her breathing pattern. Precise dosing is important in ensuring that patients receive a safe and therapeutic dose of medication. The I-neb AAD System is Respironics' third generation AAD System and is smaller, quieter and more portable than earlier product generations. The device weighs less than eight ounces and can be carried discreetly in a purse, pocket or briefcase. The I-neb device also provides audible and visual feedback to the patient informing the patient when the treatment is complete.

NEWS FEATURES

AARC SYMPOSIUM: LAS VEGAS, 2007 - HELONTIX

Helium/Oxygen Mixtures in Children: Bronchiolitis and Other Respiratory Obstruction

Federico Martín-Torres, MD, PhD

The author is with Hospital Clínico Universitario de Santiago, Spain. The following was presented at AARC 2007, at the Helontix Symposium.

Despite the apparently conflicting clinical evidence regarding its utility, heliox has gained widespread support and use in many pediatric emergency departments and intensive care units. Several potential indications have been suggested for heliox therapy, with particularly outstanding beneficial effects for patients with asthma, bronchiolitis, and upper respiratory obstructions with various etiologies.

Helium is a biologically inert gas of low molecular weight, which, when blended with oxygen, results in a gas mixture (heliox) with a markedly lower density than air (specifically, heliox with 21% oxygen has one third the density of air). Its application in the setting of obstructive airway disease will decrease airway resistance to flow, and thus reduce the work of breathing. Heliox has also been shown to enhance alveolar ventilation due to its high diffusion coefficient, which may improve carbon dioxide removal. Heliox has no inherent therapeutic effect, and thus can be used only as a temporising agent - it provides time until definitive therapies act or the subjacent pathologic circumstance spontaneously resolves. The inert nature of heliox explains the extreme rarity of secondary effects and the negligible risk of its clinical use. Interestingly, any beneficial effect of heliox should become evident in a relatively short period of time, one hour usually being sufficient.

We have extensively evaluated the therapeutic safety and efficacy of non-invasive administration of heliox, to infants with acute moderate to severe bronchiolitis: first as an initial elective treatment administered via a non-rebreathing mask with reservoir in patient spontaneously breathing; or secondly as a rescue treatment for patients refractory to the standard treatment, administered noninvasively in combination with positive pressure, via a system adapted for the use of nasal continuous positive pressure with heliox. In our experience, the elective treatment with heliox administered non-invasively to infants with acute moderate to severe bronchiolitis, via a non-rebreathing reservoir mask, improves respiratory conditions in a simple, innocuous, safe and non-invasive way. This was demonstrated by the noticeable improvement of the clinical scores, the decrease of the concomitant tachycardia and tachypnoea and the reduction in the length of stay (<2 days) in Pediatric Intensive Care Unit compared to conventional treatment.

The logistics of its application constitute a deciding issue in the final effect of heliox. In spontaneously breathing patients, heliox should be administered adequately warmed and humidified thorough non-rebreathing reservoir facemask. Additionally, its combined use with positive pressure, mainly by noninvasive ventilation but also by invasive ventilation, could have manifold complementary, if not synergistic, effects. The combination of heliox and nasal non-invasive continuous positive pressure also appears to be a safe and efficient treatment of infants with acute severe bronchiolitis refractory to standard treatments, even in those patients resistant to the treatment of heliox via a non-rebreathing mask with reservoir, demonstrated clinically (by the improvement of the clinical score and the decrease in tachypnoea) and in the improvement of the gas exchange (increase in arterial oxygen saturation and a marked reduction in the levels of carbon dioxide).

We believe that heliox may help to avoid endotracheal intubation and mechanical ventilation in some pediatric respiratory patients. Our PICU protocol for the management of acute bronchiolitis is focused on heliox therapy (alone or in combination with noninvasive ventilation). Even accepting the influence of other factors different to heliox treatment, in our experience in the management of acute viral bronchiolitis following this protocol from 1999 to date, less than 1% of the infants with bronchiolitis admitted to our PICU have required invasive mechanical ventilation.

On the basis of the existing data and our cumulated experience, we believe that heliox constitutes an effective, safe, and noninvasive respiratory treatment option in the management of pediatric patients with any acute respiratory obstructive disease. Moreover, due to the lack of a proven alternative treatment for acute bronchiolitis and considering the advantages derived from the use of heliox in this context, we believe that heliox could be considered as a first line treatment for infants suffering moderate or severe bronchiolitis.

Spontaneous Breathing Trials In Pediatrics

Justin Tse, RRT, NPS

Reprinted from Hamilton Medical's Ventilation Newsletter

Mechanical ventilation is associated with numerous life-threatening complications and should be discontinued at the earliest possible time. Weaning patients from a ventilator is one of the most complicated and challenging problems faced by physicians and respiratory therapists in the intensive care unit (ICU). The reported extubation failure rate ranges from 4.9% to 29%. There have been many studies looking at predictors of extubation failure using various respiratory measurements. These studies illustrate the efforts made by practitioners to choose the appropriate time to safely extubate pediatric patients. One thing these studies have shown is that there are currently no simple and practical tests used to predict extubation success. The current practice for extubating pediatric patients from low ventilator settings may overestimate the patient's ability to breathe independently. Practitioners today assume a low level of pressure support is adequate enough to determine the patient's readiness for extubation. A recent study challenges that assumption.

In adults, a spontaneous breathing trial (SBT) is often used to assess when a patient is ready for extubation. SBT's are not commonly used in pediatrics; therefore, very few studies have been done in this area. A study by Chavez et al looked at SBT's in infants and children to predict successful extubation.

Seventy patients ranging from full term infants (corrected gestational age greater than or equal to 37 weeks) to 18 years of age were studied. Using Mapleson flow-inflating bag, each patient received a FiO_2 of 1.00 and 5 cm H_2O of CPAP for 15 minutes. Blood pressure, respirations, heart rate and SpO_2 were the monitored parameters. These were recorded at 5 minute and 15 minute mark during the SBT. All patients were then extubated and watched over the next 24 hours for the need of noninvasive ventilation or reintubation.

Sixty – four patients passed the SBT with an extubation failure rate of 7.8 %. Six of the seventy patients failed the trial; all were then subsequently extubated in which only half extubated safely. Chavez, et al concluded a 15 minute SBT using a flow-inflating bag was a reliable bedside test. They also concluded that a trial failure is associated with but does not accurately predict extubation failure.

Should Tidal Volume Vary?

Melissa Turner, BA, RRT

Reprinted from Hamilton Medical's Ventilation Newsletter.

Generally speaking, when clinicians think about tidal volumes, it is the size of that delivered tidal volume which comes to mind. Clinical practice looks to the research such as ARDSnet to find the best clinical approach to setting tidal volumes safely. Currently, the research supports setting lower tidal volumes in the range of 5-8 cc/kg ideal body weight in acute lung injury/ARDS. Is it best to set a fixed tidal volume at all? There is research now that suggests that variable ventilation may do less harm to the lungs and significantly improves arterial oxygenation, as well as increasing alveolar surfactant. Variable ventilation is described as, "breath-to-breath variations in tidal volume (VT) and frequency."

Surfactant is produced in the lungs by specialized cells lining the lungs and its job is to maintain stability of the pulmonary tissue by decreasing the surface tension at the air-liquid interface. This is what helps to prevent collapse of alveoli and airways. It is thought that the stretching that occurs in the lung during a normal tidal breath is necessary for normal surfactant equilibrium. Ventilating the lung with high volumes has also been shown to enhance surfactant secretion within the lung. In a study by Arold et al, it was demonstrated that "by random stretching of the alveolar surface within a prescribed range, appears to promote release of chemically intact surfactant, enhancing pool size within the alveolar compartment." That increased surfactant production lowers the opening and closing pressures and therefore reduces lung injury and promotes blood arterial oxygenation. Variable ventilation uses variations in delivered tidal volume to produce random stretching of the alveolar surface and significantly increased alveolar surfactant as compared with conventional ventilation. In the study by Arold et al, it was shown that by applying variable stretch patterns to the alveoli via variable ventilation, surfactant production was amplified producing improvements in gas exchange and lung mechanics as well as recruiting collapsed regions of the lung without causing damage, as compared with conventional ventilation.

In today's practice, the new ventilation strategies are to use small tidal volumes, so as not to overstretch and injure the lungs, in tandem with optimal PEEP levels to prevent alveolar collapse and optimize oxygenation. Through these current strategies we are able to limit any further damage done to the lungs, but are unable to contribute to any reversal of the damages. Perhaps increasing surfactant production can help in that arena. It is suggested that ventilating a patient with variable tidal volumes would be a way to achieve this goal. In order to use this method of ventilation while keeping arterial blood gases stable, one would want to consider achieving the same minute volume appropriated for that patient while providing varying tidal volumes and rates.

Variability is the norm in nature. Just monitor your own spontaneous V_t over a couple of minutes and you will note the variation in V_t . In particular, you'll notice that you periodically take a sigh breath. Yes, the "sig" breath may be making a comeback!

Closed-loop control ventilation could make this method available to us today. Through employing closed-loop control ventilation, minute ventilation can be maintained while tidal volume and rate are varied. Current research is investigating what “variability index” or coefficient of variation is optimal to program into the ventilatory pattern. If variance of tidal volume can add to the benefit of the already employed lung protective strategies, then perhaps closed-loop control additionally employing ‘variation’ will be of benefit.

Sources

- Arold SP, Suki B, Alencar AM, Lutchen KR, and Ingenito EP. Variable ventilation induces endogenous surfactant release in normal guinea pigs. *Am J Physiol Lung Cell Mol Physiol* 285: L370-L375, 2003.
- Arold SP, Mora R, Lutchen KR, Ingenito EP, and Suki B. Variable tidal volume ventilation improves lung mechanics and gas exchange in a rodent model of acute lung injury. *Am J Respir Crit Care Med* 165: 366- 371, 2002.
- Boker A, Graham MR, Walley KR, McManus BM, Girling LG, Walker E, Lefevre GR, and Mutch WA. Improved arterial oxygenation with biologically variable or fractal ventilation using low tidal volumes in a porcine model of acute respiratory distress syndrome. *Am J Respir Crit Care Med* 165: 456-462, 2002.
- Faridy EE, Permutt S, and Riley RL. Effect of ventilation on surface forces in excised dogs’ lungs. *J Appl Physiol* 21: 1453-1462, 1966.
- Oyarzun MJ, Clements JA, and Baritussio A. Ventilation enhances pulmonary alveolar clearance of radioactive dipalmitoyl phosphatidylcholine in liposomes. *Am Rev Respir Dis* 121: 709-721, 1980.
- Post M and van Golde LM. Metabolic and developmental aspects of the pulmonary surfactant system. *Biochim Biophys Acta* 947:249-286, 1988.
- Suki B, Alencar AM, Sujeer MK, Lutchen KR, Collins JJ, Andrade JS Jr, Ingenito EP, Zapperi S, and Stanley HE. Life-support system benefits from noise. *Nature* 393: 127-128, 1998.
- Wirtz HR and Dobbs LG. Calcium mobilization and exocytosis after one mechanical stretch of lung epithelial cells. *Science* 250: 1266-1269, 1990.

Intelligent Ventilation In A Critically Ill Child

Melissa Turner, BA, RRT

Reprinted from Hamilton Medical’s Ventilation Newsletter.

Mechanical ventilation is a necessary evil for the critically ill child. On the one hand, it is essential to saving lives. On the other hand, it can contribute to muscle weakness, pulmonary injury, and a greater mortality. According to Wratney and Dalton, “extubation failure is common (5 percent to 27 percent) and is independently associated with a fivefold increased risk of mortality.” A child who must undergo intubation and mechanical ventilation requires careful watch and diligent care. To date, there are no set practices for weaning and extubation in the pediatric population, therefore the practices are variable.

Wratney and Dalton inform us that the mortality rate for in-hospital pediatric patients with extubation failure is 46% as

compared with in-hospital pediatric patients with successful extubation being 6.3%. “Extubation delay, or the failure to recognize the capacity for spontaneous breathing and airway control, is of significant concern in the pediatric population.” Readiness for extubation is a target that is commonly missed in this patient population. “Data have shown 63% of patients who self-extubate are able to remain successfully extubated, which may indicate patient readiness for ventilator discontinuation prior to this fact being recognized by the medical team.” With Intelligent Ventilation, readiness to wean to extubation may be identified as it occurs. Once the patient is able to breathe spontaneously, Intelligent Ventilation will allow them to do so while continuing to support the patient. Support is automatically withdrawn as the patient is able to maintain adequate ventilation on their own. If the patient is unable to maintain ventilation at any point in time, Intelligent Ventilation takes control to be sure the patient maintains a breathing pattern that is sufficient and imposes the least work of breathing. Since the patient is allowed to take over the control of breathing as their respiratory drive, strength and mechanics improve, weaning can begin at the point of patient readiness without waiting for human intervention as we do when we change from a controlled mode to SIMV to spontaneous modes. It has been shown that the “mode of ventilation used during the weaning period has no effect on ventilator length of stay or extubation success.” With Intelligent Ventilation the patient is able to switch between controlled and spontaneous ventilation as needed and as appropriate which takes the guesswork out of when to change modes and begin weaning. The whole process becomes automated and provides safe guards not available with traditional spontaneous breathing trials (t-piece or pressure support trials). As indicated by Wratney and Dalton, the following factors should be taken to consideration by the clinician as influential in successful weaning. Each of the following must be optimized for proper assessment:

- patient-ventilator synchrony via sensitive and responsive ventilator-triggering systems
- triggering threshold for the patient that optimizes spontaneous breathing
- ventilator cycling from inspiration to expiration to avoid airtrapping measuring the effective delivered tidal volume at the endotracheal tube. To effectively measure delivered tidal volume, a pneumotach should be placed at the endotracheal tube. This feature is available on some ventilators.
- assessment of residual sedative effect and/or sedative withdrawal on ventilatory drive, patient comfort, and respiratory load.

It is helpful to be able to measure the WOB, PO, and RSB in select patients. Automatic tube resistance compensation (TRC) may be useful as it more accurately proportions pressure support to overcome imposed resistive load caused by the endotracheal tube.

Intelligent Ventilation or Intelligent Ventilators are now available and can facilitate these optimization goals. These closed loop control systems represent a new era in mechanical ventilation. Hamilton Medical’s Adaptive Support Ventilation Intelligent Ventilation System has been in clinical use for 9 years. Hamilton’s Intelligent Ventilation continuously implements a set of protective rules that optimize I:E ratio, tidal volume and rate (as a result automated determination of the ‘Optimal’ breathing pattern/least work of breathing).

Another practice that may increase the risk of extubation failure is using pressure support as a means to overcome tube resistance. A common belief is that for the smaller patients the pediatric endotracheal tube imposes an excessive airway resistance. As a result, these patients often are weaned to and extubated from a pressure support of between 5 and 10 cm H₂O, a mechanical ventilator rate of 10 bpm, and a positive end-expiratory pressure of 5 cm H₂O. Often, the use of pressure support to overcome resistance of the endotracheal tube overcompensates the resistance and therefore the ability of the patient to tolerate unassisted breathing is overestimated.

Editorial Comment: Over-compensation of ETT resistance is more common with adult size ETT's. Tube Resistance Compensation (TRC), or Automatic Tube Compensation (ATC) reduces the chance of over/under compensation of ETT resistance. Tube resistance is dynamic and changes as patient flow and effort changes. The ability to compensate endotracheal tubes proportionate to the patient's flow and effort without over or underestimating is a solution to this very common problem. Tube resistance compensation is available on most ICU ventilators today.

Studies to date confirm the functionality of automated tube resistance compensation but indicate that these systems err on the side of under-compensation. However, with the wide variations in levels of pressure support observed in clinical practice, yet alone the failure to take into account the effect of different flow rates through the ETT, one could argue that automated tube compensation systems have advantages. It's also important for clinicians to understand that these systems do not support patient work of breathing due to pulmonary compliance, airway resistance, etc, so pressure support still needs to be clinically indicated!

One thing to keep in mind is that weaning success doesn't always mean successful extubation, especially in pediatric patients. One of the most common etiologies of a failed extubation in this patient population is upper airway obstruction. When the endotracheal tube is in place there is not a good way to assess upper airway competency. The air leak test is commonly performed, but has been shown that it cannot be relied upon as a predictor of successful extubation.

Successful weaning and extubation of the pediatric patient is an area that continues to be researched. According to Wratney and Dalton (see Sources), "Technically, the ability to direct ventilator weaning by a complex interaction between the patient and the ventilator with minimal direct physician input isn't far away." It is as if Wratney and Dalton could predict the future. The future of Intelligent Ventilation is now and Wratney and Dalton's prediction has become realization. Intelligent Ventilation is now available and is proving to be very successful and advantageous in the management of both adult and pediatric populations. – Paul Garbarini, MS, RRT, Hamilton Medical, Inc.

Source

Wratney AT and Dalton HJ. Weaning and extubation practices remain variable in pediatric patients. *Advance Online Editions Managers of Respiratory Care* 2006; 15(10):56.

Additional editorial commentary—As Melissa discusses, pediatric mechanical ventilation is often a double edged sword.

Her article is also supported by another recent article entitled 'Spontaneous Breathing Trial predicts successful extubation in infants and children' published in *Pediatric Critical Care Medicine*. This article makes some of the same conclusions and also calls for further research.

One of the key points in the article is ventilator synchrony. One area of interest is the proper setting of inspiratory time. I have seen inspiratory time often miscalculated for the pediatric patient. When the patient is heavily sedated, the patient is synchronous with the ventilator. The trouble begins when the sedation is lifted and the patient starts to breathe spontaneously. The patient's I-time is variable, however, the ventilator's I-time is not changed and the ventilator "fights" the patient. Closed loop ventilation is ideal because it is patient driven. As the patient transitions from control ventilation to spontaneous ventilation, I-time is flow cycled by the patient, which promotes ventilator synchrony. – Justin Tse, Pediatric Clinical Support Specialist, Hamilton Medical

Does a Single-Pressure Volume Curve Affect Oxygenation in ARDS Patients?

Tim France, BS, RRT

Reprinted from Hamilton Medical's Ventilation Newsletter

A static pressure-volume (P-V) curve has been routinely used as an assessment tool to identify a lower inflection point in order to identify the PEEP requirement for acute lung injury (ALI) or Acute Respiratory distress patients (at least the minimum PEEP requirement to prevent cyclic atelectrauma). Because of the volume and pressure that is generated with this maneuver the P-V maneuver may in and of itself at times act as a recruitment maneuver. French researchers recently studied if there were any short or long term benefits when a P-V curve was performed without changing PEEP after the maneuver, (eg examining the effect of generating a PV curve).

Researchers generated a P-V curve in two ways. First utilizing a super syringe and second by changing ventilator settings to achieve a constant flow curve. End points of this study were PaO₂, PaCO₂, mean arterial pressure and pulmonary mechanics changes. The study included 17 patients, with all having both techniques applied. Ventilator settings for all patients started at Vt 6ml/kg, PEEP 10, FIO₂ 100, plateau pressure below 35 cmH₂O. The super syringe technique was performed by instilling 100 ml of gas with a 2 second pause between each additional 100cc volume, until a peak pressure of 60 cm H₂O was achieved. After which 100ml of gas was aspirated with a 2 second pause until an airway pressure of 0 cmH₂O was achieved. The constant flow technique included changing ventilator settings until a flow of 9 l/min was achieved. Additionally, PEEP was decreased to zero end expiratory pressure (ZEEP). After both procedures were completed the patients were returned to pre-maneuver settings.

Of the 17 patients in the study only two had an increase in their

P/F ratio, with one of those returning to baseline within 2 hours after using the constant flow technique. Two other patients had a negative response or decrease in P/F ratio after using the super syringe technique. Eleven of the 17 had a lower inflection point using the super syringe technique.

According to this research study, generating a PV curve for the use of recruiting the lung seems to not have any sustainable effect on P/F ratio. Only two of 17 patients had an increase in their P/F ratio and those improvements were not sustained. If after performing the PV curve the PEEP had been changed to ~2 above the lower inflection point (LIP), would there have been more positive responders? This study chose to only look at what improvement would be realized by just doing the curve only. The problem with that approach is by recruiting the lung and keeping PEEP below the LIP you eventually will lose any lung that was recruited. The researchers fully understand that and they commented on it in the discussion section.

Hamilton Medical, as part of its Intelligent Ventilation product has tools to safely generate a low flow curve. The PV tool II on the Galileo addresses the shortcomings in the two techniques performed in the study. First, the Galileo changes ventilator settings to achieve a low flow curve utilizing a unique pressure ramping technique. Also, the PV tool II will allow a clinician to set a starting and ending PEEP. Additionally, at the end of inspiration a pause of up to 30 seconds can be applied in order to perform a recruitment maneuver. Finally, after the maneuver is completed the Galileo will automatically return the patient back to the previous ventilator settings.

Sources

Hickling K: Reinterpreting the pressure- volume curve in patients with acute respiratory distress syndrome, *Current Opinion in Critical Care* 2002, 8:32-38.

Roch A, Forel JM, Demory D, Arnal JM, Donati S, Gainnier M, Papazian L: Generation of a single pulmonary pressure-volume curve does not durably affect oxygenation in patients with acute respiratory distress syndrome. *Critical Care* 2006, 10:R85.

A high positive end-expiratory pressure, low tidal volume ventilatory strategy improves outcome in persistent acute respiratory distress syndrome: A randomized, controlled trial Jesus Villar, MD, PhD, FCCM; Robert M. Kacmarek, et al, *Crit Care Med* 2006 Vol. 34, No. 5.

EXECUTIVE PROFILE

Pari Respiratory Equipment, Inc.

Norm Tiffin

Norm Tiffin is Vice President – Marketing, Pari Respiratory Equipment, Inc.

After sale & service

Who is responsible for training and education of your staff and customers?

Lisa Cambridge, BS, RRT. Lisa Cambridge is Director, Sales Training and Clinical Development.

What types of education do you provide?

Comprehensive internal training for all new employees includes aerosol therapy, devices, respiratory anatomy, disease states, sales training, meeting customer's needs, and regulatory training. Our sales force are all Certified Aerosol Specialists, and every day teach our customers about the differences between good aerosol therapy and ineffective therapy. We are convinced, and have ample evidence, that the educated clinician will choose Pari every time. Pari also provides external CEU programs in many facets of respiratory care including aerosol therapy, COPD, asthma, and cystic fibrosis for respiratory therapists and nurses. These programs are presented by qualified healthcare professionals throughout the US and provide state-of-the-art education. Education is the core of what we do to be successful and has propelled us into the leadership position we now enjoy globally.

How do you manage "off-hours" assistance for clinical questions?

Patients and professionals have access to our Patient Connection services which is comprised of Certified Aerosol Specialists who are available to answer questions from 8 AM to 7 PM EST Monday to Friday. Pari also has registered respiratory therapists who specialize in nebulization and can answer any question that is unable to be satisfied by Patient Connection. In addition, Pari is launching a new website, pari.com, which will have more information on products, clinical data and published papers when it's complete in the spring of 2007. We are very excited about this because we know that healthcare professionals and consumers look to Pari for answers on aerosol therapy. Of course, Pari nebulizers are used in over 90% of clinical trials where jet nebulizers are used and access to internet scientific search engines, like PubMed, will yield a treasure of citations. This is in addition to inclusion on package inserts from recently introduced nebulized medications including Pulmicort, Xopenex, Brovana, and others. Because Pari is a leader in nebulized therapy we support many third party web sites, educational efforts and interest groups. Combined, these groups can reach many more end users than Pari and we will continue to support their efforts with grants, education and interaction.

What do you feel is important to support the customer/end-user of your product?

Nebulized aerosol therapy is one of the few therapies that are simple, safe and effective. However, we understand that both the first time mom with an asthmatic child and the experienced cystic fibrosis patient can ask equally important questions about their therapy. We are committed to helping them receive the best information possible about their therapy. An educated end user feels more confident and better prepared to initiate and comply with aerosol therapy. To that end we regularly participate in end-user blogs and forums to address questions and receive feedback on our products. We support end-user oriented websites from an educational standpoint, and provide patient oriented information on our website to facilitate greater understanding. Our vision is to improve the lives of those affected by respiratory diseases and those who provide care to them .

What activities does your company undertake to promote the product?

Pari's product promotion includes the standard marketing strategies which include magazine ads, trade shows, medical

conferences attendance and printed materials. However, unlike virtually any other nebulizer manufacturer, Pari reaches well beyond traditional avenues of product promotion by leveraging continuing dialogue with leading physicians in aerosol therapy, participation in clinical studies of new nebulized medications, funding of aerosol research, deep and long abiding relationships with end users and healthcare professionals who represent them and other means of interacting with and understanding our market. This is the most effective 'promotion' a company can have and we are always striving to get closer to our customers at all levels.

How does your company reach out to its customers regarding product performance and R&D?

Pari is committed to a regular quantitative, formal analysis of our customers which helps us to determine how end users, direct customers (DME, Pharmacies) and clinicians are using our products. We also send our product managers to meet with customers regularly so they are in touch with our market. Because Pari enjoys a leading position in aerosol therapy we are often considered first for partnerships, development assistance or advice within the industry. This, in addition to our own internal R&D efforts, keeps our eyes steadfastly on the goal of product innovation.

Where do you see the future of your product in relation to end-user requirements?

There is little controversy that today's goal of nebulization is about speed of treatment, once assured drug delivery has been satisfied. End users, both professionals in acute care and time challenged caregivers and patients want aerosol treatments to interrupt their lifestyle as little as possible. This is why we have developed the top selling compact compressor, the Pari Trek S - to ensure they can take a treatment where ever they go. This is also why we have decreased the treatment time of the world's leading nebulizer, the Pari LC Plus, by developing a new nozzle technology (Soft Jet Technology) which has been introduced in the Pari LC Sprint. Pari has applied their world-class aerosol expertise to the upper airway, too, and boasts the only nebulizer system that is FDA cleared for aerosol delivery to the upper airway. These and other innovations continue to drive the market on behalf of our customers and maintain Pari's dominance in innovation of nebulized medication treatments.

BLOOD GAS ROUNDTABLE

Roche Diagnostics

Larry Healy

Larry Healy is Associate Marketing Manager, Point of Care Diagnostics, Roche Diagnostics

Has your equipment facilitated results reporting through the hospital information systems, and if so, which systems interface effectively with your equipment?

Roche Diagnostics offers specific IT and Data Management solutions with the cobas b 221 system to help hospitals maximize workflow efficiency and result reporting for Respiratory Therapy, the Laboratory and POC. For example, DataCare software enables staff to effectively manage patient

data for all areas. OMNILink Instrument Manager software offers command and control of decentralized blood gas systems, and Axeda protected remote access provides virtual onsite technical support to help maximize instrument uptime. In the centralized setting of the laboratory, interfacing with the LIS/HIS through existing Middleware connections can significantly reduce the cost and set-up time for blood gas connectivity. And with RALS-Plus data management software from MAS, POC Coordinators have a single IT solution for both blood gas and glucose.

What features (ie data storage) assist you when preparing for lab inspections from JCAHO, CAP, FDA etc?

Roche offers a full suite of blood gas, IT and Web-based solutions that help simplify regulatory compliance for healthcare facilities. With 20 GB of onboard data storage, the cobas b 221 system maintains an average of five years worth of QC, calibration and patient data for review and reporting, to support users with limited or no LIS capabilities. OMNILink software allows remote screen sharing of decentralized systems and immediate access to QC, calibration, and maintenance logs from these systems. RALS-Plus and DataCare data management software reporting functions generate the necessary documentation to meet compliance standards. And eQAP offers real-time peer review of QC to help ensure system proficiency.

What do you see as an emerging trend in blood gas technology?

With the trend of managing patient health outcomes through standards of care, healthcare professionals need blood gas systems to do more in less time. As a result, blood gas systems are beginning to offer expanded menus with whole blood analysis and rapid turnaround time, which is especially beneficial in high-cost areas like the ICU and the ED.

Is point of care blood gas testing becoming widely accepted? If so, what are the benefits?

Recent market research indicates that blood gas testing is moving to the decentralized areas of the ICU, NICU, OR and ED. This trend toward point-of-care testing can offer several benefits to the healthcare facility and its patients. For example, POC blood gas testing with the cobas b 221 system can help reduce turnaround time for results and give the clinician immediate access to actionable information that can help in diagnosis, treatment decisions, monitoring the patient's condition and evaluating response to treatment.

What barriers to implementation have you seen when a POC Coordinator, RT director, lab manager or medical director decides to purchase point of care systems?

The specific barrier depends on the person's role, of course, but the most common concerns include ease of use, maintaining command and control, and making the "paradigm shift" to do testing at the point of care. Current blood gas technology offers several capabilities that help overcome those barriers, though. For example, Roche's cobas b 221 system has a multi-user interface that makes it easier for all operators to use. Staff with command and control concerns – like the POC Coordinator, RT Director and Lab Manager – have the ability to direct, monitor and report the activities of all their decentralized blood gas systems with OMNILink Instrument Manager software. And having immediate access to actionable information can make it easier to gain the medical staff's acceptance of point-of-care blood gas testing.

Compare the blood gas technology of the past with today's standard as it relates to your hospital.

Blood gas technology has evolved to match changing standards of patient care. Today, blood gas systems need to maintain a high state of readiness, deliver results faster, provide comprehensive test menus that are driven by disease states, and offer information technology solutions.

To maintain immediate readiness and ensure operator safety, most systems today are self-calibrating, without gas tanks, and have programmable onboard AutoQC. Smaller sample sizes and independent sample paths also help some systems deliver rapid turnaround on results. And analyzers like the cobas b 221 system offer additional features like continuous self-monitoring, which provides updates on pending maintenance, to increase instrument uptime.

Because test menu parameters today are driven primarily by disease states, on some systems they now go beyond basic blood gas profiles to include electrolytes, metabolites, COOX and bilirubin. The systems must have flexible sample inputs for syringes and capillaries and the ability to run whole blood, serum plasma, body fluids and dialysate. Measurement ranges have been expanded too, as a result of new cardiovascular procedures and IV therapies.

The biggest change in blood gas technology, though, is in the IT area. Information solutions like data and instrument management software, protected remote access and HIS/LIS connectivity have resulted in a true information paradigm shift in blood gas technology and in its relationship to other point-of-care testing areas.

Nova Biomedical

Harlan Polishook

Harlan Polishook is Marketing Communications Manager, Nova Biomedical

Has your equipment facilitated results reporting through information systems, and if so, which systems interface effectively with your equipment?

Nova Biomedical has adopted an industry accepted, standardized interface format on all of our analyzers that conforms to ASTM and POCT1-A protocols. Nova's Point of Care Manager combines data from multiple analyzers into a single ASTM, POCT1-A interface. Nova also partners with Telcor and Laboratory Data Systems (LDS) for middleware to automate interface of "unsolicited orders" and data from multiple vendor devices. Nova's ASTM interface and the Telcor/LDS middleware interfaces are compatible with virtually all LIS/HIS vendors.

What features (ie, data storage) assist customers when preparing for lab inspections such as DOH, CAP, FDA, etc?

All Nova Stat Profile Critical Care Xpress (CCX) analyzer models have built-in data management and automation features designed for today's regulatory requirements. When multiple analyzer management is required, data consolidation and reporting is accomplished with Nova's Point of Care Manager, Telcor, or LDS middleware. All of these platforms provide complete data capture, storage, and reporting functions, including patient results with full demographics, quality control data, instrument performance and maintenance data, operator

data, analyzer set-up and configuration data, and analyzer workload reporting.

Do you have any new developments to enhance the effectiveness of your equipment?

Nova has recently introduced total bilirubin (tBil) to the comprehensive test menu on the Stat Profile CCX. Bilirubin is an important indicator of liver function particularly in neonatal applications. With the addition of total bilirubin, the CCX analyzer now offers 20 measured tests, including pH, PCO₂, PO₂, SO₂%, hematocrit and hemoglobin, sodium, potassium, chloride, ionized calcium, ionized magnesium, glucose, BUN, creatinine, lactate, deoxyhemoglobin, oxyhemoglobin, methemoglobin, and carboxyhemoglobin, in a single, compact instrument.

We have also introduced a new feature on the CCX analyzer that allows reporting of estimated Glomerular Filtration Rate (eGFR) with the CCX serum creatinine measurement. eGFR is a calculated test that considers the effects of age, sex, and body weight on creatinine measurement, thereby adjusting serum creatinine values to more accurately reflect kidney function. The National Institutes of Health has developed the National Kidney Disease Education Program (NKDEP) that includes recommendations for reporting eGFR with every serum creatinine measurement. Many U.S. states have mandated by law that eGFR be reported with every creatinine measurement.

Is point of care testing becoming widely accepted in the marketplace? If so, what are the benefits to this?

Yes. As the acuity of patients seen in the hospital increases, the demand for point of care blood gases and other critical care tests has increased. As a result, more and more blood gas/critical care analyzers are being placed at the point of care. For example, Nova blood gas/critical care analyzers are playing a role in addressing the overcrowding crisis in the emergency department by providing improved turnaround time of urgent tests such as blood gases and Chem 7. In many institutions, respiratory therapists are playing an important role in improving patient care by providing more tests from a single sample using fewer resources and generating faster results.

What barriers to implementation have you seen when a customer decides to purchase point-of-care systems?

Nova has a comprehensive customer support program that is structured to remove any barriers to implementation. Our customer support programs provide turnkey implementation assistance, including written, customized implementation plans and timelines. Nova Technical Support personnel provide full validation, documentation, training, and onsite assistance for customers who purchase systems for point of care testing.

Can you compare the blood gas technology of the past with today's standards?

The differences are dramatic. Early blood gas technology consisted of three tests – pH, PCO₂, and PO₂. Beginning in 1980, Nova introduced a series of new biosensors that transformed the traditional, 3-test blood gas analyzer into a "critical care analyzer." Nova critical care analyzers are now capable of performing up to 20 tests on less blood than earlier blood gas-only systems. Not only has this evolution improved patient care and reduced blood use, it has also enhanced the role of respiratory therapists in improving patient care.

What is the most exciting technology advancement that you foresee in the future (near and long term)?

Among the short term advancements are expanded test menus, further automation, and reduced labor requirements. Long term we foresee the advent of continuous and less invasive technology.

facilitated the movement of blood gas analysis out of the main lab to the point of care for improved turn-around times and thus more efficient patient care while still maintaining high standards of measurement and manager control.

Opti Medical Systems

Gerri Priest

Gerri Priest is VP, Global Marketing, OPTI Medical Systems (formerly AVL).

Blood gas analyzers have evolved over the past years to incorporate easier to use graphic user interfaces, reagent packs, maintenance-free sensors and on-board automatic quality control in response to the market's needs that resulted from reduced technical staffing and the increased movement of critical care testing to the point of care. Recently, the automatic quality control feature has evolved a step further to incorporate sophisticated analyzer monitoring with automated corrective action and subsequent quality control material analyzed as needed.

OPTI Medical Systems (formerly AVL) has implemented such an innovative monitoring system called OQM (OPTI Quality Monitor) in their latest OPTI product, the OPTI R Blood Gas Analyzer. OQM is an arrangement of sensors and software that continuously monitor the performance of the OPTI R. This is performed through data analysis and corrective actions. As the OPTI R is performing calibrations and automatic quality control the OQM software is observing the recovered values and sensor behavior by comparing the run to the previous results and then by looking at the sensor response. If the system detects an error it will perform corrective actions to correct the error detected. If the error is severe and the system cannot repair it, the sensor effected will be disabled. Measurements can still be performed but the disabled parameter cannot be reported. When errors occur that result in a disabled sensor the root cause of the failure is detailed in the error report.

The OPTI R fluid pack contains three levels of QC solution that are independent from calibration solutions. All OPTI R fluid packs contain quality control solutions for use in the OQM system. This allows all users to take advantage of automatic QC without additional costs. The automatic QC program can be tailored to meet the needs of any user, with the possibility to program up to 15 QC measurements per day; even the most stringent guidelines can be met. The system can also be configured to skip automated QC measurements on Saturdays and Sundays if the facility is only in operation 5 days a week. When configuring the system to perform multiple levels at a single time, the OPTI R will schedule the samples to be run consecutively with a 1 minute pause between samples. This pause time allows for a STAT sample to be run during the automatic QC program.

The OPTI R performs 50 patient samples in a single sensor cartridge in addition to the automatic quality control measurements programmed by the user and initiated by the OQM system.

Advances in blood gas systems, such as OQM, have further

Challenges in Critical Care: The Brooklyn Hospital Center – Capnography, A Valuable Asset

Founded in 1845, The Brooklyn Hospital Center (TBHC) has become a major healthcare resource for the residents of New York City's largest borough. Equipped with the most sophisticated diagnostic and therapeutic modalities and state-of-the-art technology, TBHC is committed to excellence in patient care.

To provide the best possible respiratory care to the 200,000 patients it sees annually, the hospital has a fleet of MAQUET SERVO-i ventilators equipped with advanced functionality.

Among the SERVO-i's advanced features is an optional analyzer/monitor capable of measuring expiratory carbon dioxide (CO₂) concentrations during a respiratory cycle. Results of the measurement of CO₂, referred to as capnography, are graphically displayed on the ventilator screen in a breath-by-breath waveform, or capnogram.

The multi-disciplinary respiratory care team at TBHC finds that capnography is very useful as a noninvasive monitor for assessing ventilated patients.

While not a replacement or substitute for arterial blood gas sampling, the CO₂ analyzer allows for assessment of a placement of an endotracheal tube in the patient's airway, ventilator settings and similar measurements, says M. Shahjahan, RRT-NPS, RPFT, Director of Respiratory Care Services. The trend information that the analyzer provides is valuable for reviewing the effectiveness of changes in the ventilator, he says.

Waveform

Waveform can provide assurances and suggest when changes may be needed. To use the CO₂ analyzer, an airway adaptor is placed at the Y-piece and a sensor snapped onto the airway adapter. The CO₂ analyzer module receives signals from the infrared sensor that reflect the variations of CO₂ in the expiratory gas. The monitoring, which is continuous, is shown both in a waveform and numeric value indicating the CO₂

The views, opinions, and assertions stated by The Brooklyn Hospital Center staff members in this article are strictly those of the clinicals and administrators, and do not necessarily reflect the views of MAQUET. This article was provided by Maquet, Inc, Bridgewater, NJ, maquet.com/us.



Members of Respiratory Care Services discussing the role of CO₂ monitoring in patient care.

concentration of the end tidal carbon dioxide concentration (ETCO₂) and the rate of elimination of CO₂ or VCO₂.

Shahjahan explains that the shape of the waveform can indicate changes in the patient's condition. "If you look at the waveform, and if it is square, you know you are dealing with very good lungs and a relatively normal lung function. As the patient's lung function is improving, a squarer waveform is a very good sign."

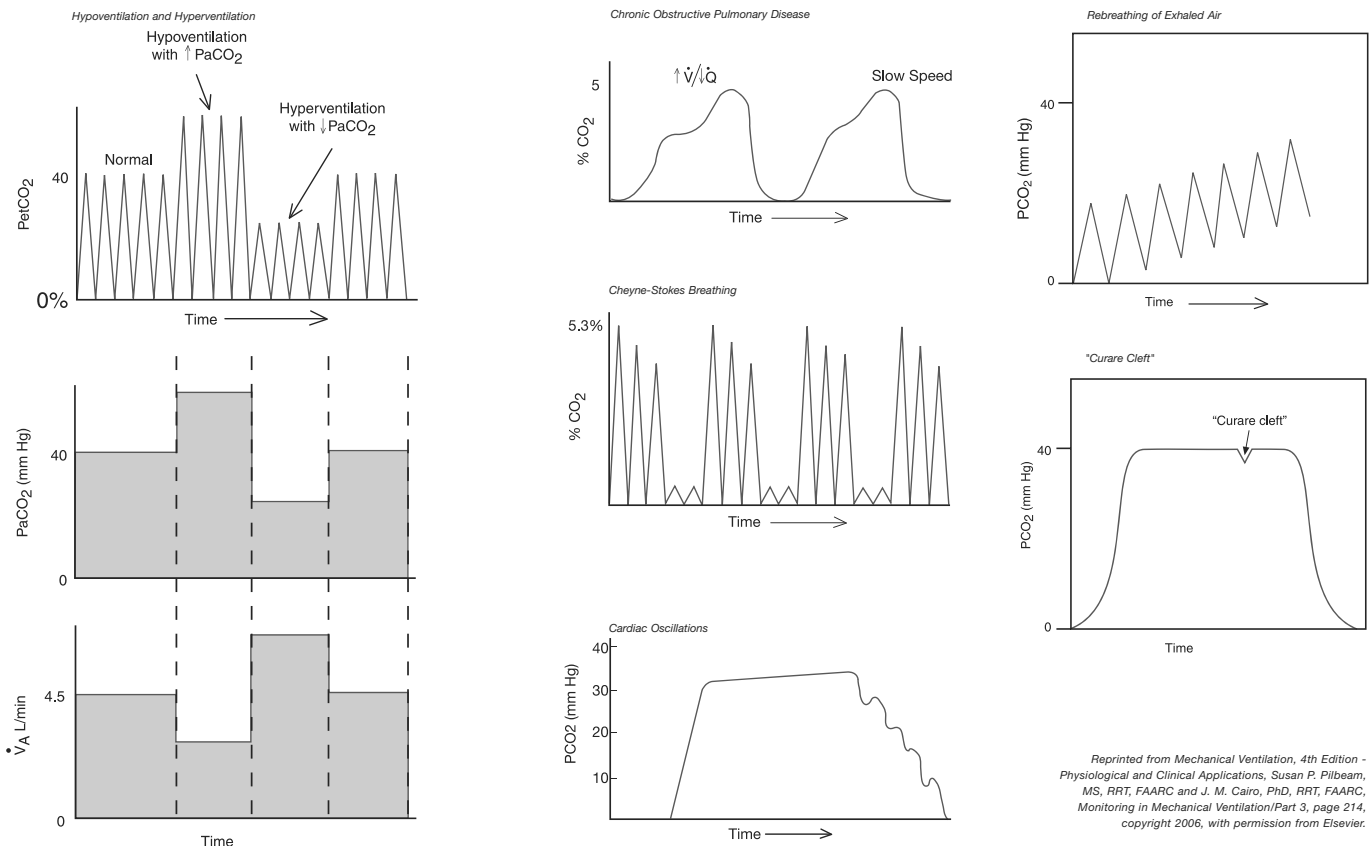
However, he says, if the waveform is non-constant (not square), it can suggest that adjustments need to be made in settings. "If the waveform is slowly rising, it tells you that you don't have uniform ventilation, and you may have to do something to aid in the resolution of the disease or clinical condition that is emerging," Shahjahan says.

CO₂ monitoring also gives the staff assurance that the ET tube is in the trachea, says Rana Ali, MD, Medical Director of the Respiratory Care Unit. Farhad Arjomond, MD, Medical Director, Respiratory Care Services, adds that the monitoring device is also very useful during recruitment maneuvers where high transpulmonary pressures may cause a fall in preload and cardiac output. "A sudden drop in ETCO₂ may mean low pulmonary perfusion; therefore, higher PaCO₂ to ETCO₂ difference."

Benefits in the OR and Pediatric ICU

The CO₂ analyzer has benefits in the OR and in the pediatric ICU. Shahjahan says the CO₂ monitoring device is of most value in the operating theater to confirm the placement and continued secure presence of the endotracheal tube in the trachea. He says

Capnograms reflective of various conditions



Reprinted from Mechanical Ventilation, 4th Edition - Physiological and Clinical Applications, Susan P. Pilbeam, MS, RRT, FAARC and J. M. Cairo, PhD, RRT, FAARC, Monitoring in Mechanical Ventilation/Part 3, page 214, copyright 2006, with permission from Elsevier.



The SERVO-i in use at bedside.

ETCO₂ monitoring works very well in the OR where airway secretions clogging the airway adapter are not a problem, since most patients receive medication to dry their airway secretions during surgery. “We had an anesthesiologist as the CEO here who insisted on using ETCO₂ monitoring in all vented patients.”

At TBHC, capnography also plays a significant role in the ventilatory management of patients in the pediatric intensive care unit (PICU).

A few years ago, Shahjahan and his colleagues presented a paper on their experience with the use of ETCO₂ monitoring at a meeting of the American Thoracic Society (ATS). The SERVO-i ventilator system is designed for use with patient populations from neonates to adults. The hospital center has 42 ventilators in its fleet; it uses the SERVO-i ventilator exclusively for patients in all age groups.

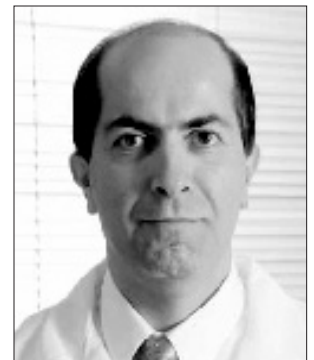
The respiratory care staff also finds that capnography can provide good assessment of hypercapnic episodes, which can be life-threatening, during weaning. If the waveform suggests an unusually high level of carbon dioxide in the blood during weaning, the procedure may need to be re-evaluated, Shahjahan says.

While TBHC’s respiratory care staff has confidence in the CO₂ measurements it sees on the SERVO-i screen, it never relies solely on them to make adjustments or changes in the patient’s care. The physicians will always confirm what they are seeing by an arterial blood gas (ABG) before making changes, Sharhajan says.

Alarm Setting

Alarm setting on the CO₂ analyzer alerts staff to issues that need quick response. It is important to remember that the success of the CO₂ analyzer depends on the clear airway adapter, Shahjahan says.

Continued on page 28...



CO₂ monitoring is valuable during recruitment, allowing heart problems to be detected early, says Farhad Arjomond, MD, Medical Director, Respiratory Care Services.



“When CO₂ is detected, it assures you that the ET tube is in place,” according to Rana Ali, MD, Medical Director of the Respiratory Care Unit.



“We had an anesthesiologist as the CEO here who insisted on using ETCO₂ monitoring in air vented patients,” says M. Shahjahan, RRT-NPS, RPFT, Director of Respiratory Care Services.

Castle Medical Center and ASV

An interview with Denise Wheatley, RRT and Ron Sanderson, MEd, DrPH, RRT, Castle Medical Center.

Denise and Ron, did the Galileo meet your expectations? Tell us about some of your experiences?

Denise: It exceeded my expectations. We had two esophageal rupture patients in ICU, severe ARDS patients, plus a very tricky surgical patient, and they survived, I think, because of the Galileo and ASV. We have had some very sick patients whose lungs were able to heal despite being ventilated. The surgeon didn't think they would survive. We've also had patients with poor cardiac function and COPD patients who were able to wean on ASV after failing traditional weaning attempts. We were able to get them off by turning down %MinVol little by little, like 5% every two days. In the year we faced some really critical patients whose oxygenation was a big problem and for whom conventional things we'd done in the past didn't work. These were turning points for us. The ability to make minute, safe changes to someone being ventilated really made a difference in outcome. I could take someone whose lungs were really collapsed, and I would keep trying and start to recruit lung until I could get the volume to a more normal level. I don't think we could have done this without a flow sensor at the airway.

Ron: I was pretty confident with Hamilton Medical's engineering. Swiss engineering is hard to beat. The patient is more comfortable because of the expiratory valve and the amount of inspiratory control. The other thing is that the Galileo accurately measures resistance and compliance. There is breath-to-breath monitoring of flow at the airway. It was really scary to transition to a proximal flow sensor at the airway, but

The Castle Medical Center uses closed-loop ventilation on 95% of their ventilated patients, for the most part right from the start of ventilation. Denise Wheatley and Ron Sanderson, a self-described "ventilator nerd," talk about their experiences with the Galileo ventilator and ASV. The Castle Medical Center is a 160-bed hospital in Kailua, Hawaii. The intensive care unit currently has eight beds. There are two respiratory therapists and hospitalists (physicians whose practice emphasizes providing care for hospitalized patients) at all times. The ICU has six Galileo Gold and one Raphael Color ventilators. This information was provided by Hamilton Medical.



Denise Wheatley (left) and Ron Sanderson.

that's where you want to do your measurement. The benefits far outweigh any problem. But the big deal was ASV.

How was your experience training on the Galileo?

Ron: The Galileo is easy and straightforward. It is low-maintenance and easy to fix. Training our people initially gave us an opportunity to bring the staff's skills up. Since we now had expiratory resistance and compliance available, we asked people to chart it and look at it and think about why the patient is on the ventilator and, how, if there was increased resistance, we could bring it back down. The machine brought us forward. It gave us the chance to in-service our staff.

How do you like the user interface?

Denise: The trends window is a little confusing, because you must turn something off to turn something on. I've been impressed by Hamilton Medical over the years, because they listen to the user and make small changes that make it easier for us, like setting the Air Trapping alarm default to off and providing one single page of monitoring information.

How do you judge the quality and reliability?

Ron: It's the best ventilator on earth and certainly reliable.

Were there concerns initially about using closed-loop ventilation?

Denise: Understanding what the ventilator was telling us was the biggest issue. The doctors were initially baffled about how to prescribe it. They're used to writing rate, tidal volume, etc. There's still a ways to go understanding what the ventilator tells them. How do you get the ICU team to understand? I tell them it takes the patient from fully supported to spontaneous with every possibility in-between. I couch it in terms of different modes that it takes you through. Then they ask, why do we need you?

Ron: Of course. The physicians were skeptical and the staff was skeptical. After we saw it work, the RRTs were really enthused, and their enthusiasm spilled over to everyone else. The nurses ended up loving it.

Tell us about the benefits you derive from closed-loop ventilation.

Denise: The patient can take a breath as soon as their muscles are able and do as much work as they are able. The patient can switch between controlled and spontaneous breaths. And the patient declares himself extubatable long before the doctor orders weaning. We don't have to wait for that morning order to do a spontaneous trial.

Ron: ASV is like having your best RRT stand at the bedside 24/7. You don't have to audit the Galileo, because it follows the protocol every time. Calling physicians after hours and debating physicians about orders have been reduced significantly.

The concern is: What's my job now? Your job is to do patient assessment and to do the interventions that don't have anything to do with the ventilator most of the time. If you've got more time to focus on patient care, it reduces needless interaction between the physician and RRT. Anecdotally the RRTs are happier and doing a better job, patients are more comfortable, nurses are happier, and physicians are happier. One big difference is that we have one-third the mortality in ASV patients. We can't explain that.

Have you seen a reduction in the patient's time on the ventilator since introducing closed-loop ventilation?

Denise: We believe that we have. We've got about 1,400 patients in our database. Those on ASV seem to have shorter ventilation times, although it's hard to prove.

How do patients respond to closed-loop ventilation?

Denise: They appear to be more comfortable and need less sedation.

Ron: They seem to be more comfortable than with conventional modes.

For what types of patient is closed-loop ventilation particularly suitable?

Ron: I think it's phenomenal for post-op, ER, and ARDS patients. We treat almost everybody with it except patients who are really tachypneic.

How do you recommend new users gain confidence in using ASV?

Ron: Try it; you'll like it. ASV is the future of mechanical ventilation.

Challenges...continued from page 26

"You have to inspect the airway adapter to make sure it is clear and only then will you be able to use it. If it is not clear, it will interfere with the infrared transmission."

The analyzer also has an alarm that can be set to indicate when CO₂ levels are too high or too low. "When you use the analyzer, it has an alarm that we set and anytime there is a deviation, the alarm will be activated so we can get to the patient's bedside immediately," Ali says.

Monitoring Capabilities

Monitoring capabilities help the hospital teach residents, and care for the elderly and critically ill patient populations. Located just across the bridge from Manhattan, TBHC, a member of the New York-Presbyterian Healthcare System, is also an academic and clinical affiliate of the Weill Medical College of Cornell University. A teaching hospital, it trains more than 250 physicians each year. Having the CO₂ monitoring capabilities on the SERVO-i is very helpful when working with residents, Ali says. "The more monitoring you have on your ventilators the better, because you have more tools to teach the residents," she explains.

Because of its location, The Brooklyn Hospital Center serves a large elderly population, many of whom are smokers. As a result, many have respiratory problems requiring mechanical ventilation, Shahjahan says. The hospital also sees a large

number of patients with sickle cell anemia and with HIV who can develop respiratory failure.

Shahjahan, who as director must keep an eye on expenditures, says that high-tech features such as capnography "are the way to go to make your job easier" while providing state-of-the-art care. "Most institutions today don't have big budgets," he says, "so the more such high tech comes into play, the more it makes your life easier, while meeting your mission of providing superior patient care."

Firefighters' Lungs: Managing Health Risks with High-Frequency Chest Compression

Jane M. Braverman, PhD; Mario J. Nozzarella

Firefighters exposed to inhalation of ultra-fine particles (UFP) may face long-term pulmonary health risks.^{1,2} Inhaled fine particles transport bacteria, viruses, fungi, allergens, and toxic substances to normally sterile lower airways.³ Injury and illness caused by inhalation of smoke and dust-borne UFP are common following major fire, explosive, or industrial disasters.⁴ Robust studies document the prevalence and persistence of a distinct pattern of respiratory pathology suffered by emergency responders and clean-up workers and by residents living near the site of the World Trade Center (WTC) disaster.⁷⁻¹⁵ Although the precise mechanisms of what is now called WTC disease are incompletely understood, it is clear that excess exposure to smoke, byproducts of combustion and the fine dust generated by structural collapse triggered an intense inflammatory response and a constellation of other symptoms in thousands of individuals.¹⁶⁻¹⁸ UFP accumulated in the smaller airways is an established etiological factor in the development of many secondary lung diseases including chronic bronchitis, emphysema, bronchiectasis and progressive massive fibrosis (PMF).¹⁹⁻²³ Cardiovascular effects are well known.²⁴ Cancer risks are suspected but unconfirmed.^{25,26}

Reflections on the aftermath of the WTC tragedy underscore the urgency of identifying strategies to protect firefighters from harmful UFP exposures.²⁷ Theoretically, at least some health consequences could have been prevented with timely use of protective respiratory gear. However, in “real-world” emergency and disaster situations, an expectation of proper and consistent use of such equipment is simply not realistic.^{28-29,42} For exposed firefighters, prompt removal of inhaled UFP may be a more practical intervention. A therapy called high-frequency chest compression (HFCC) is ideally suited to perform this function. HFCC is shown to enhance mobilization and expectoration of particulate-laden mucus from the lower airways.^{29,30} A new HCCF device, the inCourage PAC (Portable Airway Clearance), has been designed specifically to meet the needs of firefighters both on-site and in the firehouse.

Introduction

Firefighters are a vital group of public servants whose work often exposes them to hazardous conditions. Immediate risks to life and limb associated with collapsing structures, intense heat, smoke inhalation and burn injury are part of the job. Inhaled larger particles, an obvious and annoying problem, are caught in the nose and rapidly eliminated by coughing or sneezing. Less appreciated is the deposition and accumulation of ultrafine particles (UFP) that may enter the lower regions of the lung and have long-term health effects.

UFP are defined as particles of any composition less than 5 microns in diameter. Several epidemiological studies demonstrate the adverse effects of occupational inhalation of UFP among workers exposed to coal dust,³² silica,³³ asbestos^{33,35} silage³⁶ and other substances.³⁷ Until recently, however, there have been few inquiries into the health risks of inhaled UFP among firefighters.³⁸⁻⁴⁵ That neglect was corrected following the disaster that struck the WTC towers in lower Manhattan on September 11, 2001. Since that event, the focus on occupational lung disease has shifted sharply to studies involving firefighters and emergency rescue/cleanup workers. Well before the dust settled, it became apparent that health consequences were likely to be significant. Early reactions have proven prescient but vastly understated. According to one observer, WTC dust — containing everything from melted plastics, pulverized concrete, burnt jet fuel and asbestos — “may have health effects that could linger for days or weeks.”⁴⁶ Clinical evidence of serious health problems surfaced shortly after the attack. Initial studies found that many firefighters had developed “trade center cough,” a stubborn hacking that caused them to cough up soot and dust particles.^{12,13,17}

By January 2002, at least 300 firefighters were on leave for respiratory problems; that number has since grown dramatically. Approximately 40,000 rescue and recovery workers were exposed to caustic dust and toxic pollutants following the collapse of the WTC twin towers.⁴⁷ All 11,000 participating members of the Fire Department of New York (FDNY) had significant exposure because they were caught in

the dust cloud that immediately followed the building collapse and then continued to work at the site over many shifts.

A series of powerful studies detail the increasingly alarming respiratory health consequences among those exposed to by-products of combustion and structural disintegration.^{7-18, 27, 49-50}

The impact of these investigations is strengthened by the availability of on-file pre-disaster pulmonary function tests for virtually all of the FDNY emergency first responders and an infrastructure equipped to follow them longitudinally.

Among the findings, some WTC studies show a direct link between dust, smoke and chemical inhalation and specific respiratory symptoms in firefighters.^{1,4,7-14} The clinical symptoms of a distinctive type of cough, airway hyperreactivity and asthma-like symptoms persisting months and years after the WTC collapse are supported by studies linking an inflammatory process with UFP exposure.⁴⁸⁻⁵⁵ A carefully controlled induced sputum study confirmed those clinical impressions.⁴ Thirty-nine highly exposed WTC workers were screened for patterns of particulate matter deposition and bio-markers of inflammation 10 months after the event. Results showed unique patterns of inflammation and particle distribution consistent with the composition of WTC debris.

Implications for career firefighters

Few career firefighters are exposed to hazards approaching those of WTC responders. The disturbing patterns of short and longer-term health risks emerging from the WTC research have implications for all firefighters. Data on UFP deposition show that the total mass of particles accumulated during physical exertion is more than 4.5 times greater than at rest.⁵⁸ Mouth breathing also increases UFP intake.^{28, 58} A greater awareness of occupational-related impairment of the mechanisms that prevent deposition of harmful UFP in the lungs is especially important.³⁷ A review of the respiratory health effects of occupational exposures among community and forest firefighters show less dramatic but incremental lung damage. In retrospect, these findings should be cause for concern.

- An air monitoring study characterizing City of Phoenix firefighter exposures during the overhaul phase of 25 structure fires showed that one or more of the measured substances (eg respirable dust, benzene, hydrocarbons) exceeded published ceiling values in 22 of the 25 fires [Bolstad-Johnson 2000].
- Extensive measurements of smoke density found that wildland firefighters are exposed to significant levels of respirable particulate matter and other irritants and toxic gases [Reinhardt 2004].
- Firefighters' lung function decreases significantly pre-shift to post-shift [Slaughter 2004].
- The effects of routine firefighting on lung function in firefighters from a single fire showed that routine firefighting is associated with a high incidence of acute decrements in lung function [Sheppard 1986].
- An evaluation of respiratory health hazards in firefighters after fighting a 40 hour department store fire showed that PFTs were *significantly lower* in smoking firefighters compared with smoking control subjects; FEV₁ was significantly lower in non-smoking firefighters and smoking control subjects [Gu 1996].
- Most firefighters experience small decrements in pulmonary function in the short-term after exposure to house fires

(greater for current or former cigarette smokers); a subgroup is shown to develop more substantial and potentially clinically important decreases after smoke exposure [Betchley 1997].

- Cross-shift and cross-seasonal assessments of pulmonary effects in forest firefighters exposed to high concentrations of smoke showed significant mean individual declines in FEV₁, suggesting a potential for long-term adverse respiratory effects [Betchley 1997].
- Annual monitoring has shown that some firefighters have rates of FEV₁ decline far exceeding their peers. A well-powered study of firefighters with at least 6 annual FEV₁ measurements found that increased age and greater initial FEV₁ were associated with more rapid decline in lung function [Burgess 2004].
- Variations in rates of pulmonary decline may be explained, in part, in terms of variations in gene polymorphisms [Burgess 2004].
- New York City firefighters have a higher incidence of sarcoidosis than control emergency medical services and health care workers [Prezant, 1999].

Effective pulmonary defenses

In ideal circumstances, the pulmonary defense system effectively prevents air-borne particles and hot or toxic fumes from injuring the nasal passages, from invading the throat and larger central airways, and from lodging in the delicate tissues deep within the lungs. To protect the lungs from damage, the airways are equipped with mechanisms that include heat exchange capabilities in the nose and throat, cough ability, immunological responses and, most critically, the series of complex physiological structures and interactions that comprise the mucociliary clearance system (MCC).⁵⁹ Inhaled larger particles are cleared from the upper airways by triggering coughing and sneezing; smaller particles are entrapped in mucus lining the lower airways and are removed by the unidirectional "escalator" effect of the MCC; finally, alveolar macrophages and other scavenger cells ingest UFP not captured by the MCC.⁵⁴

Compromised pulmonary defenses

When otherwise healthy active-duty firefighters are exposed to large quantities of smoke, dust and debris, the pulmonary defenses begin to break down. Prolonged exposure to high concentrations of toxic substances, smoke, and particulate matter – especially UFP – overwhelms the mechanisms necessary to maintain effective clearance.⁵⁴ Mucus is hypersecreted and its biochemical/ rheological characteristics are altered in ways that defeat mucociliary transport. Thick, over-abundant secretions impede the activity of cilia, an essential component of the MCC system.⁵⁴ Cilia are the tiny hair-like structures that line the airways and, in a synchronized pattern, move mucus continuously from smaller to larger airways. When hypersecretion is severe, the risk for obstruction of the distal airways, atelectasis and development of bronchopneumonia is high. Effective mucus clearance depends upon consistent rates of mucus flow. When MCC cannot keep pace with clearance demands, some UFP successfully penetrate alveolar and interstitial spaces.⁵¹ As a consequence, the pulmonary defense system breaks down. Macrophage function is altered and a sustained inflammatory response is triggered. A complex cascade of destructive events is set in motion.

A vicious cycle of pulmonary decline

A “vicious cycle” model captures the sequence of events that may be activated by impacted deposits of UFP.⁵² Effects are significantly greater in firefighters with a history of cigarette smoking or pre-existing lung disease.^{38,43} Inhaled UFP invading smaller airways and interstitial lung regions directly or indirectly...⁵²⁻⁵⁴

- trigger inflammation/mucus hypersecretion
- overwhelm pulmonary defenses
- precipitate biochemical and rheological changes in mucus
- impair ciliary activity
- compromise cough effectiveness
- accelerate accumulation of particle-laden alveolar macrophages
- precipitate production/accumulation of harmful anti-inflammatory substances
- initiate airway obstruction/mucus plug formation
- reduce gas exchange/diffusing capacity
- diminish pulmonary function
- promote bacterial growth and colonization
- weaken immune response
- activate recurrent cycles of sustained lung inflammation and infection
- result in pulmonary and systemic diseases

Protection and prevention

The WTC tragedy underscores the urgency of identifying ways to protect firefighters from the consequences of occupational UFP exposure.⁵ At least some health effects may be prevented with use of protective respiratory gear. However, in “real-world”

emergency and disaster situations, proper and consistent use of such equipment is not a realistic expectation.^{28, 29,42} In a study of the effects of mandatory mask use, the city of Boston Fire Department reported a 52% reduction in inhalation of toxic combustible products in one year.²⁸ Unfortunately, a variety of disadvantages associated with mask use negate many of their benefits. The most effective of such devices, - self-contained breathing apparatus (SCBA) - carry a limited oxygen supply, are hot and uncomfortable and may interfere with crew communication. Such burdens may decrease maximal work capacity in firefighters required to demolish doors or walls, climb ladders/stairs and rescue people. SCBA may increase cardio-respiratory strain in workers in suboptimal physical condition. Moreover, respirator use alters breathing patterns.^{28,29,56,57} Evidence suggests that respiratory gas exchange is diminished.^{29,56} Increased physiological and psychological stress may result. Experts recommend that use of SCBA should be limited and interrupted by significant rest periods.^{28,57} Compliance studies that show incorrect and inconsistent use of SCBA and other protective respiratory devices is common.^{27,57} Although respiratory gear is an important component of firefighter protection, it is not a complete solution.

High frequency chest compression (HFCC) for firefighters: A novel strategy

A therapy called high-frequency chest compression (HFCC) is ideally suited to clear excess mucus and inhaled UFP from the airways. First introduced for clinical use in 1988, HFCC was initially prescribed to augment mucus clearance in individuals with cystic fibrosis (CF)^{30, 31} CF is an inherited disorder characterized by the production of large quantities of



State-of-the-art Airway Clearance Technology

- Technical Advances
- Design Improvements
- Comfort Features



Today's most advanced high-frequency chest compression therapy.



abnormally thick, tenacious mucus. Without assistive interventions, CF patients suffer frequent, severe infections, rapid lung deterioration and early death. Striking improvements in PFT stability, general health and survival among CF patients have encouraged physicians to prescribe HFCC for patients with any condition characterized by MCC impairment such as bronchiectasis, chronic bronchitis and dyskinetic ciliary disorders.^{30,58-61} HFCC therapy has been prescribed to manage lung problems tied specifically to inhaled UFP, most notably in coal miners with pneumoconiosis associated with coal dust exposure.

The inCourage PAC

For exposed firefighters, prompt on-site or routine post-shift in-firehouse removal of inhaled UFP may be a more practical intervention. A new HCF device, the inCourage PAC (Portable Airway Clearance), has been designed specifically to meet emergency airway clearance needs and ongoing maintenance therapy. HFCC with the inCourage PAC is easy to administer and can be performed in any setting with access to a power source. Users secure an inflatable wrap-like garment over their chest and connect two tubes to both the garment and a pulsating therapy unit (PTU). When activated, rapid compressions of the chest wall produce oscillations within the airways that increase airflow velocities and create brief changes in lung airflow patterns similar to coughing. Physiological effects are threefold: 1) mucus adherent to bronchial walls is loosened;⁶²⁻⁶⁴ 2) thick secretions are physically altered, thus enhancing clearability⁶⁴⁻⁶⁶ and; 3) an airflow bias mobilizes particle-laden secretions toward central airways for elimination by coughing or expectoration.^{62-64,67} Measurements of tracheal mucus clearance rates (TMCR) show that HFCC increases mucus mobilization up to 240% of that achieved by healthy MCC systems.⁶² Radioactive tracers attached to carbon particles demonstrate cephalad movement of mucus from smaller to larger airways.⁶⁷ HFCC-induced interruption of glycoprotein bonds favorably alters mucus rheology to enhance mucus-mobilizing ciliary activity.^{61, 63-66}

Up-to-date reviews on the management of fire-associated inhalation injury routinely advocate airway clearance interventions to remove both excess mucus and particulate matter.⁶⁸ In its most recent guideline document, the American Physical Therapy Association (APTA) recommends airway clearance therapy with modalities including mechanical techniques for chest wall manipulation/percussion/vibration (ie HFCC) to manage lung problems caused by UFP.⁶⁹ The guidelines include ICD-9 codes for conditions including coal workers' pneumoconiosis and other pneumoconioses due to silica or silicates, due to other inorganic dust, due to other dust, due to unspecified inhaled matter and due to asbestosis.⁶⁹

Anticipated benefits

For firefighters with occupational exposure to byproducts of combustion, on-site and post shift HFCC treatments may be expected to:

- improve clearance of particle-laden airway secretions
- enhance cough function
- reduce work of breathing
- improve gas exchange
- increase physical endurance
- enhance health, wellness and fitness
- improve work-related quality of life

- reduce absenteeism and job-related healthcare costs
- reduce risk for long-term lung disease

Summary

Lung function is directly related to lung health; decreasing lung function is a consistent occupational risk factor among firefighters and is strongly associated with quality of life deficits, progressive illness and premature mortality. The health consequences of overexposure to UFP are clear. Compelling studies, including WTC disaster-related investigations, demonstrate the adverse effects of UFP on lung defenses, mucus production and clearance, and on pulmonary function. Indisputably, UFP contribute to the development of a broad range of pulmonary and systemic diseases. Acute and long-term respiratory damage is prevalent following major fire, explosive, or industrial disasters. In the light of such evidence, interventions are urgently needed that will modify the impact of occupational exposures among firefighters, rescue workers and civilians. Both basic research and extrapolated clinical experience support the rationale for firehouse use of HFCC. Routine use of aggressive airway clearance therapy with the inCourage PAC may be a simple, reliable and effective way to reduce risk for occupational lung injury among firefighters.

References

- 1 Banauch GI, Hall C, Weiden M, Cohen HW, Aldrich TK, Christodoulou V, Arcentales N, Kelly KJ, Prezant DJ. Pulmonary function after exposure to the World Trade Center collapse in the New York City Fire Department. *Am J Respir Crit Care Med.* 2006 Aug 1; 174(3):312-319.
- 2 Herbert R, Moline J, Skloot G, Metzger K, Baron S, Luft B, Markowitz S, Udasin I, Harrison D, Stein D, Todd A, Enright P, Stellman JM, Landrigan PJ, Levin SM. The World Trade Center disaster of the health of workers: five-year assessment of a unique medical screening program. *Environ Health Perspect.* 2006 Dec; 114(12):1853-1858.
- 3 McClellan, RO. Particle interactions with the respiratory tract. In: P Gehr and J Heyder, Eds. *Particle-Lung Interactions.* [C Lenfant, Executive Editor: *Lung Biology in Health and Disease*, Vol 143, Marcel Dekker New York 2002]. pp. 3-63.
- 4 Fireman EM, Lerman Y, Ganor E, Greif J, Fireman-Shoresh S, Liou PJ, Banauch GI, Weiden M, Kelly KJ, Prezant DJ. Induced sputum assessment in New York City firefighters exposed to World Trade Center dust. *Environ Health Perspect.* 2004 Nov; 112(15):1564 - 1569.
- 5 Moline J, Herbert R, Nguyen N. Health consequences of the September 11 World Trade Center attacks: a review. *Cancer Invest.* 2006 Apr-May; 24(3):294-301.
- 6 Mauderly JL, Cheng YS, Hoover MD, Yeh, HC. Particles inhaled in the occupational setting. In: P Gehr and J Heyder, Eds. *Particle-Lung Interactions.* [C Lenfant, Executive Editor: *Lung Biology in Health and Disease*, Vol. 143, Marcel Dekker New York 2002]. pp. 89-170.
- 7 Banauch GI, Hall C, Weiden M, Cohen HW, Aldrich TK, Christodoulou V, Arcentales N, Kelly KJ, Prezant DJ. Pulmonary function after exposure to the World Trade Center collapse in the New York City Fire Department. *Am J Respir Crit Care Med.* 2006 Aug 1; 174(3):312-319.
- 8 Lin S, Reibman J, Bowers JA, Hwang SA, Hoerning A, Gomez MI, Fitzgerald EF. Upper respiratory symptoms and other health effects among residents living near the World Trade Center site after September 11, 2001. *Am J Epidemiol.* 2005 Sep 15; 162(6):499-507.

- 9 Banauch GI, Dhala A, Prezant DJ. Pulmonary disease in rescue workers at the World Trade Center site. *Curr Opin Pulm Med* 2005; 11(2): 160-168.
- 10 Banauch GI, Dhala A, Alleyne D, Alva R, Santhyadka G, Krasko A, Weiden M, Kelly KJ, Prezant DJ. Bronchial hyperreactivity and other inhalation lung injuries in rescue/recovery workers at the World Trade Center Collapse. *Crit Care Med*. 2005 Jan; 33(1 Suppl):S102 -106.
- 11 Herbstman JB, Frank R, Schwab M, Williams DL, Samet JM, Breyse PN, Geyh AS. Respiratory effects of inhalation exposure among workers during the clean-up effort at the World Trade Center disaster site. *Environ Res* 2005; 99 (1): 85-92.
- 12 Banauch GI, Alleyne D, Sanchez R, Olender K, Cohen HW, Weiden M, Kelly KJ, Prezant DJ. Persistent hyperreactivity and reactive airway dysfunction in firefighters at the World Trade Center. *Am J Respir Crit Care Med*. 2003 Jul 1; 168(1):54-62.
- 13 Prezant DJ, Weiden M, Banauch GI, McGuinness G, Rom WN, Aldrich TK, Kelly KJ. Cough and bronchial hyperresponsiveness in firefighters at the World Trade Center. *NEJM* 2002; 347 (11): 806-815.
- 14 Reibman J, Lin S, Hwang SA, Gulati M, Bowers JA, Rogers L, Berger KI, Hoerning A, Gomez M, Fitzgerald EF. The World Trade Center respiratory health study: new-onset respiratory symptoms and pulmonary function. *Environ Health Persp* 2005; 113 (4): 406-411.
- 15 Geyh AS, Chillrud S, Williams AL, et al. Assessing truck driver exposure at the world trade center disaster site; personal and area monitoring for particulate matter and volatile organic compounds during October 2001 and April 2002. *J Occup Environ Hygiene* 2005; 2 (3): 179-193.
- 16 Herbert R, Moline J, Skloot G, Metzger K, Baron S, Luft B, Markowitz S, Udasin I, Harrison D, Stein D, Todd A, Enright P, Stellman JM, Landrigan PJ, Levin SM. The World Trade Center disaster of the health of workers: five-year assessment of a unique medical screening program. *Environ Health Perspect*. 2006 Dec; 114(12):1853-1858.
- 17 Nemery B. Reactive fallout of World Trade Center Dust. *Am J Respir Crit Care Med*. 2003; 168: 2-3.
- 18 Liou PJ, Weisel CP, Millette JR, et. Al. Characterization of the dust/smoke/aerosol that settled east of the World Trade Center (WTC) in lower Manhattan after the collapse of the WTC 11 September 2001. *Environ Health Perspect*. 2002; 110: 703-714.
- 19 Born PJ, Wouters EFM. Forward. Special Issue: Coal Dust-induced Respiratory Disorders. *Exper Lung Res*. 1994; 20 (5): 381-383.
- 20 Oxman AD, Muir DC, Shannon HS, Stock SR, Hnizdo E, Lange HJ. Occupational dust exposure and chronic obstructive pulmonary disease. *Am Rev Respir Dis* 1993; 148: 38-48.
- 21 Hnizdo E, Combined effect of silica dust and tobacco smoking on mortality from chronic obstructive pulmonary disease in gold miners. *Br J Ind Med* 1990; 47; 656-664.
- 22 Briche A, Wallert B, Gosselin B, et al. "Primary" diffuse interstitial fibrosis in coal miners; a new entity? *Rev Mal Respir*. 1997; 14 (4): 277-285.
- 23 Viegi G, Maio S, Pistelli F, Baldacci S, Carrozzi L. Epidemiology of chronic obstructive pulmonary disease: health effects of air pollution. *Respirology* 2006; 11(5): 523-532.
- 24 Frampton MW. Systemic and cardiovascular effects of airway injury and inflammation: ultrafine particle exposure in humans. *Environ Health Perspect*. 2001; 109 Suppl 4: 529-532.
- 25 Schwarze PE, Ovreivik J, Lag M, Refsnes M, Nafstad P, Hetland RB, Dybing E. Particulate matter properties and health effects: consistency of epidemiological and toxicological studies. *Hum Exp Toxicol* 2006; 25 (10): 550-579.
- 26 Moline J, Herbert R, Nguyen N. Health consequences of the September 11 World Trade Center attacks: a review. *Cancer Invest*. 2006 Apr-May; 24(3):294-301.
- 27 Feldman DM, Baron SL, Bernard BP, Lushniak BD, Banauch G, Arcentales N, Kelly KJ, Prezant DJ. Symptoms, respiratory use, and pulmonary function changes among New York City firefighters responding to the World Trade Center disaster. *Chest* 2004; 125: 1256-1264.
28. Brown NS, Health Hazard Manual for Firefighters: Exposure to Chemicals and Toxic Gases. Chemical Hazard Information Program, Cornell University. New York State Department Labor Grant # COO5413.
- 29 Donovan KJ, McConnell AK. Do firefighters develop [specific ventilatory patterns in order to cope with exercise whilst wearing self-contained breathing apparatus? *Eur J Appl Physiol Occup Physiol*. 1999 Jul; 80(2):107-112.
- 30 Dosman CF, Jones RL. High-frequency chest compression: a summary of the literature. *Can Respir J* 2005; 12(1): 37-41.
- 31 Braverman J, Nozzarella MJ. High-frequency chest compression: advanced therapy for obstructive lung disease. *Respir Ther* 2007; April/May: 50-52;56.
- 32 Born PJ, Wouters EFM. Forward. Special Issue: Coal Dust-induced Respiratory Disorders. *Exper Lung Res*. 1994; 20 (5): 381-383.
- 33 Driscoll KE, Lindenschmidt RC, Maurer JK, Higgins JM, Rider G. Pulmonary response to silica or titanium dioxide: inflammatory cells, alveolar macrophage-derived cytokines, and histopathology. *Am Rev Respir Cell Mol Biol* 1990; 2; 381-390.
- 34 Lin RT, Takahashi K, Karjalainen A, et al, Ecological association between asbestos-related diseases and historical asbestos consumption: an international analysis. *Lancet* 2007; 369 (9564): 844-849.
- 35 Boffetta P. Health effects of asbestos exposure in humans: a quantitative assessment. *Med Lav* 1998; 89 (6): 471-480.
- 36 Spurzem JR, Romberger DJ, Von Essen SG. Agricultural lung disease. *Clin Chest Med* 2002; 23 (4): 795-810.
- 37 Frampton MW. Inflammation and airborne particles. *Clin Occup Environ Med* 2005; 5(4): 797-815.
- 38 Gu TL, Liou SH, Hsu CH, Hsu JC, Wu TN. Acute health hazards of firefighters after fighting a department store fire. *Ind Health* 1996; 34(1): 13-23.
- 39 Slaughter JC, Koenig JQ, Reinhardt TE. Association between lung function and exposure to smoke among firefighters at prescribed burns. *J Occup Environ Hyg*. 2004 Jan; 1(1):45-49.
- 40 Booze TF, Reinhardt TE, Quiring SJ, Ottmar RD. A screening-level assessment of the health risks of chronic smoke exposure for wildland firefighters. *J Occup Environ Hyg*. 2004 May; 1(5):296-305.
- 41 Bolstad-Johnson DM, Burgess JL, Crutchfield CD, Stormont S, Gerkin R, Wilson JR. Characterization of firefighter exposure during fire overhaul. *AIHAJ*. 2000 Sep-Oct; 61(5):636-641.
- 42 Burgess JL, Nanson CJ, Bolstad-Johnson DM, Gerkin R, Hysong TA, Lantz RC, Sherrill DL, Crutchfield CD, Quan SF, Bernard AM, Witten ML. Adverse respiratory effects following overhaul in firefighters. *J Occup Environ Med*.

- 2001 May; 43(5):467-473.
- 43 Betchley C, Koenig JQ, van Belle G, Checkoway H, Reinhardt T. Pulmonary function and respiratory symptoms in forest fires. *Am J Ind Med.* 1997; 31 (5): 503-509.
 - 44 Large AA, Owens GR, Hoffman LA. The short-term effects of smoke exposure on the pulmonary function of firefighters. *Chest* 1990; 97 (4): 806-809.
 - 45 Prezant DJ, Dhala A, Goldstein A, Janus D, Ortiz F, Aldrich TK, Kelly, KJ. The incidence, prevalence and severity of sarcoidosis in New York City Firefighters. *Chest* 1999; 116 (5): 1183-1193.
 - 46 E. J. Mundell. *New York Times.* (Reuters Health).9/11 by the Numbers:
<http://nymag.com/news/articles/wtc/1year/numbers.htm>
 - 47 Safirstein BH, Klukowicz A, Miller R, Teirstein A. Granulomatous pneumonitis following exposure to the World Trade Center Collapse. *Chest* 2003; 123 (1): 301-304.
 - 48 Salzman SH, Moosavy FM, Miskoff JA, et al. Early respiratory abnormalities in emergency services police officers at the World Trade Center site. *JOEM* 2004; 46 (2): 113-122.
 - 49 Skloot G, Goldman M, Fischler D, et al. Respiratory symptoms and physiologic assessment of ironworkers at the World Trade Center disaster site. *Chest* 2004; 125: 1248-1255.
 - 50 Demarest GB, Hudson LD, Altman LC. Impaired alveolar macrophage chemotaxis in patients with acute smoke inhalation. *Am Rev Respir Crit Care Med.* 1979; 119: 279-286.
 - 51 Cole, PJ. Inflammation: a two-edged sword-the model of bronchiectasis. *Eur J Respir Dis* 1986; 16 (Suppl 147): 6-15.
 - 52 Wedzicha JA, Mechanisms of exacerbation. In: *Chronic Obstructive Pulmonary Disease: Pathogenesis to Treatment.* Novartis Foundation Symposium 234; (John Wiley and Sons, New York, 2001).
 - 53 Samet JM, Cheng PW. The role of airway mucus in pulmonary toxicology. *Environ Health Perspect.* 1994; 102 (suppl 3): 89-103.
 - 54 Mlcak R. Smoke inhalation injuries require careful attention. *Advance for MRC.* 2001; 11: 48-52.
 - 55 Louhavaara V, Smolander J, Tuomi T, et al. Effects of an SCBA on breathing patterns, gas exchange and heart rate during exercise. *J Occup Med* 1985; 27: 213-216.
 - 56 Rand Corporation. Performance and availability of Personal Protective Equipment. [Ch 3; pp. 21-25].
http://rand.org/pubs/conf_proceedings/CF176/CF176.ch3.pdf.
 - 57 Warwick WJ, Hansen LG. The long-term effect of high-frequency chest compression therapy on pulmonary complications of cystic fibrosis. *Pediatr Pulmonol* 1991; 11:265-271.
 - 58 Anbar RD, Powell KN, Iannuzzi DM. Short-term effect of ThAIRapy™ Vest on pulmonary function of cystic fibrosis patients. *Am J Respir Crit Med* 1998; 157 (Suppl 3): A 130.
 - 59 Burnett M, Takis C, Hoffmeyer B, Patil S, Pichuko B. Comparative efficacy of manual chest physiotherapy and a high-frequency chest compression vest in inpatient treatment of cystic fibrosis. *Am Rev Respir Dis* 1993; Suppl 147: A30.
 - 60 Wilenski CL, Warwick WJ. Change in pulmonary function over a 30-month period for high-frequency vest users vs. Non-users in a cystic fibrosis population. *Am J Respir Crit Care Med* 1996; 153; A71.
 - 61 Chang HK, Weber ME, King M. Mucus transport by high-frequency nonsymmetrical oscillatory airflow. *J Appl Physiol* 1988; 65(3): 1203-1209.
 - 62 King, M, Phillips DM, Gross D, Vartian V, Chang HK, Zidulka A. Enhanced tracheal mucus clearance with high frequency chest wall compression. *Am Rev Respir Dis* 1983; 128 (3): 511-515.
 - 63 King M, Phillips DM, Wight D, Gross D, Chang HK. Tracheal mucus clearance in high frequency oscillation: effect of peak flow rate bias. *Eur Respir J* 1990; 3 (1): 6-13.
 - 64 Tomkiewicz RP, Biviji A, King M. Effects of oscillating air flow on the rheological properties and clearability of mucous gel simulants. *Biorheology* 1994; 31 (5): 511-520.
 - 65 Majaesic CM, Montgomery M, Jones R, King M. Reduction in sputum viscosity using high frequency chest compression compared to conventional chest physiotherapy. *Pediatr Pulmonol* 1996 ;(suppl 13):A358.
 - 66 Gross RJ, Zidulka A, O'Brian C, Wight D, Fraser R, Rosenthal L, King M, Peripheral mucociliary clearance with high-frequency chest wall compression. *J Appl Physiol* 1985; 58 (4); 1157-1163.
 - 67 Mandel J, Hales CA. Smoke inhalation. UpToDate(r)
www.uptodate.com
 - 68 Guide to Physical Therapy Practice. *Physical Therapy* 2110; 81 (1): S489-S504.

The Flow Characteristics of the VORTRAN E-Vent Case Manifold System

Introduction

During the national statewide disaster drills, many health care facilities realized the finite limit of ventilators determines the number of patients that can be managed in any mass casualty incident (MCI). Under the Hospital Preparedness program, the bureau awards grant money to states who allocate, to as many hospitals as possible within the designated regions, to strengthen the ability of hospitals and other health care facilities to respond to bio-terror attacks, infectious disease outbreaks and natural disasters that may cause MCI.*

It is recognized, that the VORTRAN Automatic Resuscitator (VAR), a pneumatically driven automatic resuscitator, provides the best clinical options as to location (not all triage sites have A/C power), portability, relative ease of use and the most cost effective way of providing basic mechanical ventilation to a large number of patients.

Packaging the VARs in the VORTRAN E-Vent Case (Figure A), with all your emergency procedures and supplies, allows for rapid emergency ventilator deployment in any MCI.

The E-Vent Case gas distribution manifold system is engineered specifically for operating multiple VARs from a single gas source (oxygen, compressed air or oxygen enriched air). For added robustness while operating in the field, the manifold is mounted on a sturdy stand. The manifold inlet is connected to the gas source via a twenty foot (20') heavy duty oxygen hose. The supplied gas pressure is adjustable using the manifold mounted pressure regulator and pressure gauge. Each of the seven (7) outlets is fitted with male thread oxygen DISS fitting with auto shut off. The manifold system can support up to seven (7) VARs operating from the single gas source. The VAR is a completely pneumatic driven resuscitator that runs on a continuous flow of compressed gas. Typically, hospital supplied gas is regulated to 50 PSIG and the system is capable of providing sufficient flow to meet the demand of medical equipment.

However, in the emergency situation, with limited resources, preparing for an emergency means knowing the capacity and



Figure A -
E-Vent Case
packages with
the VARs

limits of your facility. Understanding your gas supply is essential in determining the numbers of surge capacity ventilator patients the facility can manage. The VARs and E-Vent Case offer tools to help you meet your needs but it is not the complete solution. You also need trained clinicians and sufficient gas resources. This report details the flow requirements and operational characteristics of the VARs using the E-Vent Case manifold system. Using the flow requirement information provided herein, there are many alternative gas distribution systems that the hospital's biomedical department can develop to achieve the same result. To safely and effectively operate multiple VARs from a single gas source, make sure your gas distribution can provide the flow (liters per minutes) to meet the demand.

Setting up the manifold

Setting up the E-Vent Case manifold distribution system for multiple VARs is easy. Follow the five quick steps [1] – [5]:

- 1 Connect to a gas source. Connect the other end of tubing to manifold inlet (Figure B).
- 2 Set patient flow to 25 LPM with pressure gauge at 25 PSIG (Figure C).
- 3 Connect patient (Figure D).



Figure B - Manifold is connected to source gas via a 20' tubing



Figure C - Set manifold pressure using the regulator and pressure gauge

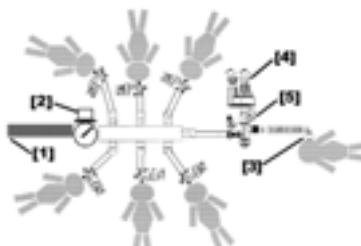


Figure D - Connect patients



Figure E - Adjust PIP and rate

Table A1 – VAR is operated in the 100% FiO₂ mode with green colored connector when manifold pressure is set to 50 PSIG

No. of VARs connected to manifold		1	2	3	4	5	6	7
Supplied source pressure	(PSIG)	51	52.5	55	58	62	67	73
Total flow requirement	(LPM)	42	83	125	166	208	249	291
Averaged flow to each VAR	(LPM)	42	41.5	41.6	41.5	41.6	41.5	41.6

Table B1 – VAR is operated in the 50% FiO₂ mode with grey colored connector when manifold pressure is set to 50 PSIG

No. of VARs connected to manifold		1	2	3	4	5	6	7
Supplied source pressure	(PSIG)	50	50	51	51	52	53	54
Total flow requirement	(LPM)	16	31	47	62	78	93	109
Averaged flow to each VAR	(LPM)	16	15.5	15.6	15.5	15.6	15.5	15.6

Table A2 – VAR is operated in the 100% FiO₂ mode with green colored connector when supplied source pressure is set to 50 PSIG

Nos of VARs connected to manifold		1	2	3	4	5	6	7
Manifold pressure	(PSIG)	49	47	45	43	40	37	34
Total flow requirement	(LPM)	41	79	114	147	173	196	214
Averaged flow to each VAR	(LPM)	41	39.5	38	37	34.5	33	30.5

Table B2 – VAR is operated in the 50% FiO₂ mode with grey colored connector when manifold pressure is set to 50 PSIG

Nos of VARs connected to manifold		1	2	3	4	5	6	7
Manifold pressure	(PSIG)	50	50	49	49	48	47	46
Total flow requirement	(LPM)	16	31	46	61	75	89	102
Averaged flow to each VAR	(LPM)	16	15.5	15.3	15.3	15	15	14.5
Delivered flow w/entrainment	(LPM)	~40	~40	~40	~40	~40	~40	~40

Table 3 - Estimate delivered flow rate (LPM) for each patient

Delivered flow	Set manifold pressure	
	100% FiO ₂	50% FiO ₂
20 LPM	25 PSIG	10 PSIG
25	30	20
30	40	30
35	45	40
40	50	50

- 4 Adjust PIP and rate for patient's needs (Figure E).
- 5 Verify PIP with a manometer.

Methods of Evaluation

The E-Vent Case manifold system is connected to a compressed air source using the twenty foot (20') oxygen hose supplied. This bench top evaluation was conducted using the following two (2) scenarios:

- When the gas source supplied is capable of maintaining a constant 50 PSIG pressure to the manifold
- When the gas pressure supplied is limited to maximum of 50 PSIG

In each scenario, *i* and *ii*, the VAR is operated in both the [A] 100% FiO₂ mode and in the [B] 50% entraining mode to simulate oxygen consumption. In both cases, compressed air (21% FiO₂) is used and flow rate is measured. The density of the oxygen compared to the density of room air makes an insignificant difference in the flow measurements herein. At each pressure setting, flow from each individual VAR is recorded and summarized in Tables A1, B1, A2 and B2.

Table A1 indicated the maximum flow of 291 LPM when operating 7 VARs in 100% mode. This requires the source pressure to be at 73 PSIG in order to maintain a 50 PSIG manifold pressure. Although this is not common, due to regulated hospital source gas pressure, it demonstrated that the manifold can deliver maximum flow to 7 VARs. Table B1 indicated the flow demand is significantly less when operating in entrainment mode.

When the supplied source pressure is regulated to 50 PSIG, adding or removing VARs to the manifold will result in a pressure drop as indicated in Table A2. When operating all 7 VARs from a 50 PSIG gas source, the maximum flow available to each VAR will be 30 LPM. The pressure drop in the entrainment mode as shown in Table B2 is significantly less with a lower flow demand and maximum flow can be delivered for up to 7 VARs.

Conclusions

The E-Vent Case manifold system demonstrated that it can sustain up to 7 VARs operating simultaneously. The key is to understand the supply pressure capability of the gas source (compressed air or oxygen). It is critical for each facility to evaluate the gas supply system in order to prepare for any surge capacity incidents.^{1, 2, 3}

When connected, all patients on the same manifold system will receive the same amount of flow (LPM) regardless of their individual clinical situation. Any adjustment made on supply pressure will affect all patients connected to the manifold and flow is estimated to be within ±15% (see Table 3).

*Health Resources and Services Administration (HRSA). HRSA works to fill in the health care gaps for people who live outside the economic and medical mainstream. The agency uses its \$7.4 billion annual budget (FY 2005) to expand access to quality health care for all Americans through an array of grants to state and local governments, health care providers and health professions training programs. HRSA'S Special Programs Bureau provides \$660 million in programs and services.

References

- 1 Donald G. McNeil Jr., Hospitals Short on Ventilators if Bird Flu Hits, New York Times, March 12, 2006.
- 2 Dan Hanfling, MD, Equipment, Supplies, and Pharmaceuticals: How Much Might It Cost to Achieve Basic Surge Capacity? Acad Emerg Med Volume 13, Number 11 1232-1237, published online before print June 26, 2006.
- 3 Frederick M. Burkle, Jr., MD, MPH, Population-based Triage Management in Response to Surge-capacity Requirements during a Large-scale Bioevent Disaster. Acad Emerg Med Volume 13, Number 11 1118-1129, published online before print October 2, 2006.

Utilization of Infrared Trans-illumination as an Aid for Peripheral Arterial Access (IRIS Vascular Viewer)

Michael R. Dunn, MD; Shawn Conrad, MD

Objective

The utilization of infrared and near-infrared light to exploit the absorptive qualities of hemoglobin through trans-illumination of peripheral vessels has previously been hypothesized and recently developed as a means for improved vascular access. The objective of this study was to evaluate the effectiveness of this technology in assisting with arterial blood gas sampling in the emergency setting.

Methods

This experimental study was a prospective, randomized, controlled trial performed at an urban, teaching institution with an annual emergency department census of 46,000 patients. During 2004, 58 patients requiring a diagnostic arterial blood gas as part of their clinical care in the emergency department were consented then randomized to either study group or control group. In the study group, infrared trans-illumination was used (using the IR Viewer, a device manufactured by Infrared Imaging Systems, Inc) as an aid in localizing and cannulating the artery while the control group used traditional blind arterial palpation. Outcomes measured included time required for the procedure as well as the number of skin sticks, vessel sites used, and ABG kits used.

Results

30 patients were enrolled in the study group and 28 in the control group. Mean time required for the procedure in the study group was 8.73 min. (95% Confidence Interval 5.74-11.73) vs. control group 16.0 min. (95% CI 12.87-19.06) $p=0.001$. Mean number of skin sticks in the study group was 1.70 (95% CI 1.29-2.11) vs. control group 2.93 (95% CI 2.49-3.36) $p=0.000$. Mean number of peripheral arterial sites used for the study group was 1.10 (95% CI .94-1.25) vs. control group 1.43 (95% CI 1.27-1.58) $p=0.004$. Mean number of ABG kits utilized in the study group was 1.14 (95% CI .91-1.38) vs. control group 1.71 (95% CI 1.48-1.95) $p=0.001$. The results are tabulated in Table 1.

Conclusions

Infrared trans-illumination is a very effective aid for peripheral ABG access, providing significant performance improvement over the traditional, unaided method.

Author's note: Subjects were asked to rate the pain experience on a scale of 1 to 10, and practitioners were asked to rate the difficulty of the procedure on a similar scale. In both categories, subjects and practitioners reported that perception of pain and difficulty of procedure with the infrared visualization device were nearly half that without the device, typically around 3 out of 10 with the device vs. 5 to 6 out of 10 without.

	Control Group (blind palpation)	Study Group (infrared transillumination)	% Δ
Mean time of ABG procedure (min.)	16.0	8.73	↓ 45%
Mean # of skin sticks	2.93	1.70	↓ 42%
Mean # of arterial sites	1.43	1.10	↓ 23%
Mean # of ABG kits used	1.71	1.14	↓ 32%

Table 1. Comparison of ABGs performed by blind palpation and infrared transillumination.

The authors are with Allegheny General Hospital: Pittsburgh, PA. Portions presented as an Original Research Abstract at the Society for Academic Emergency Medicine 2005 Annual Meeting found in part in Academic Emergency Medicine, Volume 12, Number 5 Suppl. 1 34-35, © 2005, Society for Academic Emergency Medicine, © InfraRed Imaging Systems Inc, 2005. For more information contact IRIS, (614) 486-5940, sales@irimagesys.com, www.irimagesys.com.

A close-up, low-angle photograph of a woman's face, tilted slightly to the left. Her eyes are closed, and she has a gentle smile. Her dark hair is pulled back, and several autumn leaves in shades of yellow, orange, and red are scattered around her face and hair, some appearing to be resting on her skin. The background is a soft, out-of-focus green, suggesting an outdoor setting. The overall mood is peaceful and serene.

SLEEP INTERNATIONAL

THE GLOBAL JOURNAL OF SLEEP MEDICINE

Sleep Roundtable
Executive Profiles
Sleep Apnea
Negative Expiratory Pressure
Sleep Studies

Editorial Advisory Board

Andrew DesRosiers, MS, RRT, RPSGT
Caritas Christi Health Care System
Program Director, Neuro/Ortho/ICU
Caritas Centers for Sleep Medicine
Methuen, MA

Marion Boyd Gillespie, MD, ENT Surgeon
Medical University of South Carolina
Charleston, SC

Roop Kaw, MD
Assistant Professor of Medicine
Section of Hospital and Perioperative Medicine
Cleveland Clinic Foundation
Cleveland, OH

Rebecca A. Mabry
General Sleep Manager
Viasys Healthcare, Yorba Linda, CA

News

□ June-July 2007

INFLAMED

Patients with moderate to severe sleep apnea who have significantly higher serum levels of inflammatory markers that serve as precursors to coronary artery disease, as well as lesions associated with silent brain infarction, have an elevated risk of stroke, according to a group of Japanese medical researchers, reported *Medical News Today*. Researchers at Showa University School of Medicine in Tokyo studied silent brain infarction, brain tissue death from lack of blood supply, in 50 male patients with obstructive sleep apnea. The researchers also examined the effects of three months of treatment with nasal continuous positive airway pressure (nCPAP) on serum inflammatory marker levels in 24 male patients who had moderate to severe OSA. Research results showed that occurrence of stroke in patients with OSA is likely preceded by subclinical cerebrovascular disease, or silent brain infarction, which is detectable with brain magnetic resonance imaging (MRI). The lesions identified as silent brain infarction were either wedge-shaped or round and showed up in brain white matter on MRI scans. The investigators noted that cardiovascular disease is commonly characterized by ongoing inflammatory responses that can enhance platelet activation and increase the prevalence of silent brain infarction. They found that use of nCPAP, a treatment designed to reduce the number of episodes of breathing stoppage associated with sleep apnea, significantly lowered serum levels of C-reactive protein and the levels of the two platelet-activating proteins, all associated with cerebrovascular disease. As such, nCPAP may be an important treatment intervention for decreasing the cerebrovascular risk in this susceptible population of obstructive sleep apnea patients.

EAT YOUR HEART OUT

Cardiovascular disease can pose a threat to both men and women. While a diet rich in fat and high in cholesterol as well as lack of exercise can contribute to cardiovascular disease, a

study published in the journal *SLEEP* finds that people with OSA are at an increased risk of having cardiovascular disease. The study, which attributes the increased link between OSA and cardiovascular disease to heightened recognition and perhaps a rising prevalence, found mounting data suggesting a potentially important causative role of OSA in cardiovascular disease, particularly systemic hypertension, bolstered by well-described pathophysiologic responses to apnea and hypopneas. Recently published longitudinal cohort studies have strengthened previously recognized associations with stroke and mortality from cardiac events. According to the researchers, there is abundant physiologic evidence implicating OSA in perpetuating, if not enticing, heart failure. In addition to their association with systemic hypertension, OSA-related stressors, including hypoxemia, increased sympathetic drive, acute surges in blood pressure, and mechanical effects of intrathoracic pressure swings, have varying effects on myocardial oxygen supply and demand, particularly in the already compromised heart..

ON YOUR MARKERS

Recent research shows sleep disruptions as potential markers of prothrombotic cardiovascular risks. In a study from the University of California San Diego, researchers performed full-night polysomnography in 135 unmedicated patients, who had no history of sleep disorders. Three different types of antigens, morning fasting plasma levels of von Willebrand Factor (VWF), soluble tissue factor (sTF), and plasminogen activator inhibitor (PAI-1), and D-dimer were gathered and determined. Also, statistical analyses were adjusted for age, gender, ethnicity, body mass index, blood pressure, and smoking history. Results showed that measures of sleep fragmentation and sleep efficiency were related to VWF and sTF, and apnea-related measures were related to PAI-1. Researchers conclude that sleep disruptions, even in a relatively healthy population, are associated with prothrombotic changes. This study appears in the March issue of *CHEST*, the peer-reviewed journal of the American College of Chest Physicians.

KEEPS ON TICKING

Researchers have gained new insight into the workings of biological clocks, according to *Medical News Today*, citing a recent study at the University of Georgia. A UGA research team discovered how three genes in *Neurospora crassa* - bread mold - make such a clock tick at the molecular level. The research describes how to identify genetic networks and show how the tools of systems biology can yield insights into what makes the clock tick. The discovery also has broad implications for understanding biochemical signaling and other regulatory processes in cells. Before this research, there has been little experimental support for any of the many existing models of the biological clock. The UGA team studied actions of three genes in *Neurospora*: white-collar-1, white-collar-2 and frequency. The team found that the products of these three genes constitute the building blocks of a biological clock. The discovery crosses species boundaries, since human beings have a gene analogous to white-collar-1.

SIT UP STRAIGHT

When a person lies down, a small amount of fluid displaced from the legs to the base of the neck can narrow soft tissue around the throat and increase airflow resistance in the pharynx by more than 100 percent, predisposing the person to obstructive sleep apnea. So says a report published in the *American Journal of Respiratory and Critical Care Medicine*.

Researchers measured leg fluid volume, neck circumference and airflow resistance in the throats (pharynx) of 11 healthy, non-obese subjects while they lay on their backs. Next, the researchers applied a lower body positive pressure device (anti-shock trousers) for five minutes to displace fluid from the legs to the neck area. The study pointed out that a factor not ordinarily considered when dealing with apnea is fluid accumulation at the nape of the neck and around pharyngeal soft tissue. Obstructive sleep apnea is very common in fluid-retaining states such as heart failure, renal failure and peripheral edema of unknown cause. Research data showed that displacement of a small amount of fluid such as 340 ml, about 12 ounces, from the legs is sufficient to cause a 102% increase in airflow resistance of the pharynx in healthy, non-obese subjects. According to the authors, when the pharynx narrows in obstructive sleep apnea and in healthy subjects, airflow resistance increases as the person transits from wakefulness to sleep. Consequently, an even greater degree of fluid shift into the neck during sleep would cause further pharyngeal airflow obstruction. The authors noted that further studies would be required to determine whether fluid displacement increases pharyngeal obstruction as a person moves from upright to a recumbent position, especially when the person does not have a predisposing condition.

REMEMBER

Patients with obstructive sleep apnea may improve their memory by using CPAP, according to a recent study in CHEST. The study showed that the majority of patients with OSA who were memory-impaired prior to treatment demonstrated normal memory performance after 3 months of optimal CPAP use. The study also showed that memory improvement varied based on CPAP adherence. Patients who used CPAP for at least 6 hours a night were nearly eight times as likely to demonstrate normal memory abilities compared with patients who used CPAP for 2 or fewer hours a night. Researchers examined the degree to which varying levels of CPAP adherence improved memory in 58 memory-impaired patients with clinically diagnosed OSA. All patients underwent cognitive evaluation involving verbal memory testing prior to initiation of CPAP and at a 3-month follow-up visit. Patients were prescribed CPAP machines, and adherence was covertly monitored using internal microprocessors within each device. At baseline, all patients were found equally impaired in verbal memory, with the average verbal memory score being approximately 2 SD below the mean for all participants. Following 3 months of CPAP treatment, 21 percent of poor users, 44 percent of moderate users, and 68 percent of optimal users demonstrated normal memory performance. Compared with poor users, optimal users of CPAP were nearly eight times as likely to demonstrate normal memory abilities. Overall, the average verbal memory score for all patients improved approximately 1 SD.

ZAP THE ZZZs

Prescription sleep aids may do little to improve the use of continuous positive airway pressure among patients with obstructive sleep apnea. A recent study by researchers at the Naval Medical Center in San Diego, CA found that patients with OSA who were given prescription sleep aids were no more likely to use their CPAP machines than patients with OSA taking a placebo. Researchers noted that CPAP treatment improves daytime alertness and quality of life for most patients with OSA and may prevent some of the long-term complications of this disorder, including heart attacks and strokes, but that many

people find CPAP difficult to use. People with a good initial experience are more likely to use CPAP regularly. As such, the research team hypothesized that a sleeping pill might help new CPAP users adjust to sleeping with the equipment and promote long-term usage. To determine the effect prescription sleep medications have on CPAP compliance, researchers compared CPAP use among 72 newly diagnosed male patients who were referred for CPAP treatment. All patients participated in standardized CPAP training and were randomized to receive zolpidem, a placebo pill, or standard care with no sleeping pill or placebo. Patients taking zolpidem or placebo were instructed to take one pill each night, 30 minutes prior to bedtime for the first 14 days of treatment. During the four-week trial, CPAP use was recorded by an internal data chip. Compared with the placebo pill and standard care groups, the zolpidem group did not show greater CPAP usage in terms of total days used or average time used per night over the course of four weeks. When the initial 14 days of CPAP treatment were analyzed separately, there was also no difference in number of days used or average nightly use. Despite results, researchers believe prescription sleep medications, when used correctly, may prove helpful for a subset of patients with OSA. Upon completion of the trial, all patients showed significant symptom improvement on the Epworth Sleepiness Scale and Functional Outcomes of Sleep Questionnaire. Baseline demographics revealed no difference in age, body mass index, ESS, FOSQ, nadir oxygen saturation, or CPAP pressure setting among the three groups. Despite randomization, the standard care group had a higher apnea/hypopnea index than the other two groups.

SLEEP PRODUCTS

TAKING LICENSE

Respironics, Inc announced that the FDA granted 510(k) clearance of the BiPAP autoSV device, which is intended to provide noninvasive ventilatory support to treat adult patients with OSA and respiratory insufficiency caused by central and/or mixed apneas and periodic breathing. The BiPAP autoSV device was previously launched in Europe and Canada and to date the market acceptance of this product has been very positive. This product is designed for managing complicated sleep-disordered breathing patients and combines a number of Respironics' core technologies to recognize and respond to patients' changing pressure needs. The BiPAP autoSV device delivers optimal therapy for these complicated sleep-disordered breathing patients utilizing a multi-level algorithm. On a breath-by-breath basis, the revolutionary algorithm utilizes Respironics' core technologies to adjust pressure support upon detecting a sleep event, such as an apnea, hypopnea or periodic breathing, to stabilize the patient's breathing pattern. This algorithm also calculates the patient's spontaneous breathing rate and will automatically trigger a breath for the patient should a sleep event occur. This device also combines Respironics' proven BiPAP technology, Encore Pro Data Management Software, Digital Auto-Trak Sensitivity, integrated alarms and optional integrated heated humidification. Contact respironics.com.

PHONE HOME

Cleveland Medical Devices Inc (CleveMed) announced that it recently conducted the first virtually attended sleep study using mobile phone broadband internet service from a subject's home. The study was performed using CleveMed's proprietary wireless

technology and medical communication system to provide real-time transmission of polysomnography data. This new technology combined with CleveMed's established wireless PSG systems can now allow a technologist to perform virtually attended sleep studies from almost anywhere in the world. The Crystal Monitor 20-B is a wireless 14 channel PSG system for diagnosing sleep-disordered breathing. Unlike sleep screeners that only collect a limited number of physiological signals, the Crystal Monitor 20-B is a complete PSG system that collects all of the relevant data needed for proper sleep diagnosis including EEG, ECG, EMG, EOG, airflow, snore, thoracic and abdominal respiratory efforts, body position and pulse oximetry. Because a large number of homes in the United States and around the world still are without high speed internet access, CleveMed's system utilizing the mobile phone broadband network allows for virtually attended studies to be performed in almost any setting, regardless of the patient's personal access to the internet. During the virtually attended study, a sleep technologist monitored the PSG signals and video in real-time from several miles away. Because the data is monitored in real-time, the sleep technician was able to view the data in a supervised manner that is comparable to a study done in the sleep lab where the sleep technologist monitors the patient in the next room. "The diagnostic power of in-lab evaluation, combined with the convenience and cost effectiveness offered by the home environment, would benefit millions of patients who suffer from sleep disordered breathing, their doctors and the insurance companies," said Hani Kayyali, CleveMed President. Potential applications include pediatric studies, pharmaceutical research for drug development, and studies for patients who are unable to go to sleep labs.

SLEEP ROUNDTABLE

Actigraph

John G. Schneider

John Schneider is with ActiGraph.

What products do you offer for diagnostics?

We have two diagnostic products right now, both activity monitors. Our main product is the ActiGraph GT1M for sleep monitoring. The other is our brand new ActiTrainer, which incorporates heart rate data from world renowned Polar® with the ActiGraph's physical activity data.

What are the latest trends for such products?

The trends for using the ActiGraph are for doctors to use them for screening patients who complain about sleep problems, pain management, exercise compliance, and rehabilitation efficacy.

How has technology changed in the past several years?

The changing technology has helped us in making our instruments much easier to use, reducing their size and cost, as well as making them more reliable.

Please discuss your company's current R&D efforts.

We are presently pursuing wireless technology for our ActiGraph products. We see many more uses and opportunities for a wider market by developing this capability and our main R & D efforts are in that area.

How does your product deal with electronic records management?

From the very start ActiGraph's products have been electronically downloadable using the standard ASCII (text) format. This allowed the Centers for Disease Control & Prevention to provide over 2 gigabytes of data for public release on the first two years of its national research program (NHANES) while using our ActiGraph physical activity monitor.

What clinical trials have been performed on your device?

We have had numerous trials and validation on the ActiGraph. Presently the University of South Carolina is investigating the ActiGraph's ability to accurately score sleep while being worn on the waist. Though the study is not yet finished, it appears that the finding will be favorable to actigraphy. This could allow physicians to study both daily activity and sleeping without having the patient move the ActiGraph from waist to wrist.

What is the level of clinical evidence supporting the use of your device?

The AASM has presented many papers and articles over the last 3 to 4 years indicating the wider use and acceptance of actigraphy in sleep clinic settings. We are also seeing a rapid increase in sleep clinics and general doctor's offices requesting information and purchasing the GT1M ActiGraph.

Does your product have portable monitoring capability?

Actigraphy is the ultimate in portability for sleep monitoring. The ActiGraph can be worn similar to a watch on the wrist or to a pager on the waist – free of any cords. The unit can be initialized and simply given to a patient to be worn overnight. The device is then returned and the data downloaded by either a clinician or physician.

How can your product improve patient compliance?

The ActiGraph acts as an impartial jury. It measures movement, so if you prescribe an exercise regimen, the data will show what movement was made during the wear of the device. If it is either not worn, or the patient is not compliant, the data will show the lack of activity, both with number charts and pictorial graphs.

How can your product improve patient outcomes?

A patient who knows they are being monitored will more than likely do as prescribed, and thus improve their outcome and/or comply with doctor orders. In sleep analysis, the ActiGraph will clearly tell whether the patient has a sleeping problem or not. This will prevent longer analysis periods which will, in turn, benefit both patient and sleep clinics.

Please discuss cost-savings/benefits for both purchasers and patients using your products.

The use of actigraphy has been granted a temporary billing code of 0089T. This would provide the purchasers a means of billing insurance for reimbursement, which would save patients from having to pay for the ActiGraph out of their own pocket. Another cost saving benefit to the patient would be if the sleep scoring from the ActiGraph (used as a precursor to more invasive sleep diagnostics) shows the patient does not have a sleep problem they would not have to pay for a night in the sleep clinic. With wider use the ActiGraph could eventually become a screening device for the general public, possibly increasing the need for full sleep clinic analysis and weeding out those without sleep problems.

Viasys Healthcare, Inc.

Steve Birch

Steve Birch is Director of Marketing, Sleep Diagnostics and Therapeutics, Viasys Healthcare, Inc.

What products do you offer for diagnostics? What are the latest trends for such products?

VIASYS's SomnoStar Pro sleep diagnostics system is a global leader in sleep disorders center based data acquisition and analysis systems. The SomnoStar Pro is a very capable and flexible system that allows clinicians to configure the system and its output to their needs. The SomnoStar Pro system incorporates respiratory inductive plethysmography (RIP) technology that gives the clinician a uniquely detailed perspective into the patient's respiratory efforts. Calibrated signals help to assess the degree of obstruction and the Flow Volume Loops that are displayed provide a graphical reduction of complex information and allow the clinician to more easily titrate therapy.

One of the trends in polysomnography is focused on improved assessment of upper airway obstruction with the intent to provide improved therapy. Calibrated RIP is one of the more significant advances and there is an interest in volumetric calibration to provide an even better assessment. A second trend is developing in the areas of data management, data transfer and process management. This trend is becoming increasingly important as sleep disorders centers continue to grow and become more networked.

What products do you offer for therapy? What are the latest trends for such products?

VIASYS is currently expanding and developing a complete line of new therapy devices ranging from patient interfaces to CPAP devices and beyond. With the acquisition of Tiara Medical Systems VIASYS can now offer a complete range of patient interfaces, including nasal and full faces masks as well as a direct nasal interface and accessories. The acquisition of Hoffman Laboratories BreatheX CPAP technologies provide us with a platform off which we can launch new compact, quiet and efficient therapy devices. These technologies position us to establish new trends in OSA therapy that allow patients to integrate treatment into their lifestyles. Clearly, the small size of therapy devices is an ongoing trend as are reduced sound level. Compact battery power that affords true portability is another trend that helps patients to use their therapy systems where they are needed.

How has technology changed in the past several years?

Clearly, CPAP systems are getting smaller and the integration of humidification is now expected. Improved comfort of the delivery of pressure has also been seen in some areas, but this has not yet become the standard as it should be.

Please discuss your company's current R&D efforts.

VIASYS has research and development efforts focused on all areas of sleep diagnostics and therapy. Sleep diagnostic development is a continual process that is periodically punctuated with new product releases. A large portion of this R&D effort is invested in evolving the diagnostic software to provide the best product for all of our customers. Multiple teams are working on various efforts in the sleep therapy from

the evolution of our patient interfaces to the development of new therapy devices.

How does your product deal with electronic records management?

The SomnoStar Pro system interfaces to our Lab Manager software for the management and transfer of PSG records. This software allows access to the numerous people that are involved in the collection, scoring, over-reading if needed and report generation and final reporting. Lab Manager also has a DME function that allows the tracking of therapy devices and the management of patients in an on-going fashion.

Please discuss your assistance programs and training programs for purchasers and/or patients.

VIASYS has recently released the V-Care program and it is now available on our VMAX PFT system and the SomnoStar Pro PSG system. This tool allows for remote access to the system for troubleshooting and assistance. This provides the user with real time support that has been otherwise unavailable for PSG systems. Additionally, the VIASYS Clinical Support staff, staffed extensively by registered sleep technicians, is available 24/7 for direct access to address any technical problems that may arise.

Our training programs are extensive and provide for in-house and classroom training on the SomnoStar Pro system. Additionally, we offer mask fitting workshops that qualify for AARC continuing education credit.

The RIP technology that is central to the respiratory monitoring function of the SomnoStar Pro system has been widely tested regarding both the calibration process and the on-going monitoring of breathing patterns. The use of Flow Volume Loops for the monitoring of breathing pattern changes has also been widely studied in the clinical setting.

All of our systems and software releases are tested in the clinical environment prior to release. These tests are conducted with experienced sleep clinicians and are documented to assure the optimal performance of every product.

What is the level of clinical evidence supporting the use of your device?

The RIP technology has been widely studied and level one and two research has demonstrated the function and utility of this aspect of the SomnoStar system. We look forward to working with researchers as our new systems are released to conduct additional research.

Does your product have portable monitoring capability? If so, please discuss.

VIASYS does have two portable sleep monitoring systems in addition to a portable version of the SomnoStar. Additionally we are engaged in the development of new portable sleep monitors to address the growing demand for these systems with technology that interfaces with our existing PSG devices. These systems are compact and possess a feature set that addresses the global need for portable monitoring.

How can your product improve patient compliance?

VIASYS designs all of our therapy products with the patient in mind. We appreciate the challenges associated with regular use of CPAP and strive to find ways to reduce these challenges for the patient. Whether it's a quieter CPAP system or one that can

be powered by a battery, we're designing our product to address the issues that give rise to non-compliance. The BreatheX is one of the quietest CPAP systems on the market. The battery power feature means that you can use your CPAP system in almost any setting.

How can your product improve patient outcomes?

Improved patient outcomes are vitally important to the future of sleep medicine and to our continued ability to provide therapy to patients. The impact of non-treatment or inadequate treatment is that the co-morbidities that appear to arise from OSA will develop into a costly problem for global healthcare delivery. These problems, including heart disease, diabetes and metabolic disorder represent a growing healthcare expense. We believe that CPAP technologies that are easily integrated into patient lifestyles and that provide comfortable treatment are most likely to be complied with. The BreatheX technology is quiet, comfortable to breathe on and is highly efficient such that it can be used for up to 12 hours on a small battery pack. This allows patients to continue to utilize CPAP when they are traveling or are in remote locations. This will help promote continued utilization.

VIASYS provides technologies that deliver a high value to the clinicians and providers as well as patients. Our reliable PSG platform and extensive support system provides maximum up time which reduces cancellations and rescheduling which does result in costs to both provider and patient. On the therapy side VIASYS is continually looking for ways to reduce manufacturing costs while producing a high quality and innovative product. Our R&D efforts are continually looking for ways to provide high levels of functionality at the lowest possible cost. As the adoption of CPAP therapy continues to grow this approach will be increasingly important since the total cost will become a target for payors.

Compumedics

Tom Lorick

Tom Lorick is with Compumedics

What products do you offer for diagnostics? What are the latest trends for such products?

Compumedics offers one of the widest ranges of PSG diagnostic tools in the market. Compumedics has a unique approach to delivering comprehensive solutions by offering a 3 step approach to purchasing the perfect system for each lab. First, choose the fixed, wireless or ambulatory amplifier system that best suits your needs. Second, choose the optimum mix of acquisition, analysis and review packages from our all new Profusion 3 software suite. Third, choose from data handling options including NeXus Lab Management System, Nexus secured remote access, and the level of HIS interface or HL7 connectivity you require. It really is a "pick and choose" solution to scale the right solution from a single bed lab up to a multiple bed, multiple facility installation with worldwide remote review capabilities and full data interface with the Hospital Information System (HIS). And with the continuing interest in home-based PSG diagnostics, Compumedics is established as a market leader from development of our P-Series system used for the Sleep Heart Health Study, to the Somté limited 8 and 5-channel recorders to the all-new 16-

channel SomtéPSG system recently released in Australia and pending FDA market clearance in the USA.

What products do you offer for therapy? What are the latest trends for such products?

Currently Compumedics does not offer therapy products, though we support a variety of data integration options from many existing manufacturers.

How has technology changed in the past several years?

Primarily everything has been driven by two factors, ever increasing computing requirements and the need for paperless, comprehensive data integration. At Compumedics we are working diligently to develop software that takes full advantage of increased computing power, and by developing tools to streamline labs and make the use of our systems easier. Sleep studies are simultaneously becoming simpler (in ease of use) and more complex (in data handling requirements and flexibility). The recent resurgence of interest in automatic scoring processes is another area that Compumedics has anticipated with its current products and ongoing R&D efforts.

Please discuss these R&D efforts.

As stated above, we are constantly evolving our products to meet market needs. For instance, our just released ProFusion3 software extends on the popularity of our renowned diagnostic software by adding features that streamline the workflow in the lab, automate more mundane tasks and add tools that help with the latest lab accreditation requirements. Other projects in the works focus on our presence as a world wide market innovator and the needs of the different healthcare environments in different countries. For instance, while unattended studies are currently not reimbursed in the USA, we have several products in other markets that address this niche in unique ways that allow us to leverage work that has originally been tailored to the USA marketplace.

How does your product deal with electronic records management?

Compumedics introduced our extremely powerful NeXus Lab Management System in 2004. NeXus is a patient-centric product; it allows all data associated with any one patient to be kept in a single record. NeXus is our key to integrating with Hospital HIS systems and for complete paperless lab operation. Through NeXus we offer a complete HL7 connectivity solution that allows us to interface with many of the established hospital systems on the market such as EPIC and Cerner to name only two; in fact Compumedics is one of only two manufacturers currently certified to operate with the US Government VA and VISTA worldwide data records systems.

Please discuss your assistance programs and training programs for purchasers and/or patients.

At Compumedics we believe that the systems can only reach their true potential excellence if the people using them feel comfortable and well trained on all aspects of the system. We provide a variety of solutions including on-site, custom tailored training courses per facility, regional courses and corporate office based training options. Recently we have added a full range of online training for our users so that they can work one-on-one with our trainers in the comfort of their own lab. We don't believe in simply "dropping a system and letting the customer fend for themselves." We offer continuing education opportunities throughout the year. These cost-effective regional

opportunities bring the training closer to our customers and are tailored to meet the needs of the individual attendees.

What clinical trials have been performed on your device?

Compumedics is most proud to have been chosen as the vendor for the Sleep Heart Health Study, with over 20,000 studies recorded; plus many follow-up research trials also selected the Compumedics systems. We are currently working with several facilities on trials that, due to various agreements, cannot be discussed in any detail at this time. Compumedics systems have always been developed to provide the critical data required by researchers' worldwide, and offer flexible software tools such as MATLAB compatibility, Software Developer Kits and data export in a variety of formats.

What is the level of clinical evidence supporting the use of your device?

As we are celebrating our 20th anniversary, and over 10,000 systems installed I think that we have some pretty impressive credentials! However, I'd again point to the Sleep Heart Health Study, as well as our development institutions in Australia and the USA to clearly demonstrate our clinical acceptance.

Does your product have portable monitoring capability? If so, please discuss.

Compumedics offers several models that address portable or ambulatory requirements. Our Siesta802 series allow a lab to be set up virtually anywhere as its Wi-Fi connection eliminates the need for most cabling requirements. Our Safiro is an exceptional ambulatory EEG monitor and finally we have the unique Somte which offers respiratory sleep recording capabilities as well as a complete cardiac analysis package.

How can your product improve patient compliance?

The best way to garner patient compliance in PSG studies is to make the set-up, calibration and data collection routines as unobtrusive and fast as possible, thus allowing the patient to rest for the study. We have designed our software to streamline the patient set-up and in addition offer tools like our exclusive QuikCap PSG. The QuikCap PSG provides faster set-up, faster clean-up and several measures of quality control that can get the patient set-up, and cleaned up faster for a better overall sleep lab experience.

How can your product improve patient outcomes?

Because we are in the diagnostic side of the sleep market, the best thing we can do is provide the highest quality of data, along with the analysis tools to help make an accurate and comprehensive diagnosis. Our NeXus Lab Management System provides many tools to help in tracking and reporting patient outcomes.

Please discuss cost-savings/benefits for both purchasers and patients using your products.

Compumedics has taken the approach that good diagnostics make for good medicine. Therefore we focus on quality data. We offer cost-effective solutions that are scalable. We do not just focus on the cost of the amplifiers but look at time savings, infrastructure reduction, and data integration tools that reduce or eliminate a lot of labor intensive tasks. In order to realize the true value to any lab the goals and desired outcomes have to be evaluated, and the systems and solutions need to be scalable to the specific lab in question. Compumedics has taken the total approach to offer every required diagnostic product from a

single source. Therefore Compumedics is one of the only manufacturers that develops, builds, sells, installs, trains and services everything required for a successful diagnostic lab. We manufacture everything in house from our sensors and amplifiers to our QuikCaps, we write our own software code, and we provide the extensive network and data integration services required in today's modern and increasingly paperless lab. It is our goal to be the one-stop value provider for everything in sleep diagnostics from the home to the research focused lab.

XLTEK

John Mumford

John Mumford is President and CEO of XLTEK.

What products do you offer for diagnostics?

XLTEK currently offers a complete line of polysomnography equipment including fixed, portable, and ambulatory systems. We also provide diagnostic testing equipment for EMG, EEG, epilepsy monitoring, and intra-operative monitoring.

Please discuss current R&D efforts.

One project we're working on right now is to combine our diagnostic knowledge and experience with PAP therapy to improve compliance and outcomes for patients with OSA. The problem we see with PAP therapy today is that there is no way to objectively determine the effectiveness of therapy with respect to sleep quality despite the fact that many patients will still have poor sleep due to comfort issues, co-morbidities, pressure settings, or other reasons. Currently it's left up to the patient to seek help if they feel the therapy isn't working but unfortunately people are more likely to just stop using the device when that happens. That leads to poor compliance and outcomes. We've spoken to many clinicians who would love to be able to monitor their OSA patients' breathing and sleep quality once on therapy so they can intervene promptly – before the therapy is rejected - when necessary. Measuring sleep quality is especially important because the patient's perception is based on their sleep, not breathing. If a patient is breathing well with PAP but not sleeping well then they'll still feel tired and decide that PAP isn't worth the effort because it doesn't make them feel any better even though their long-term cardiovascular risks may be reduced. There is nothing on the market that can provide this information to the clinician in a cost, time, and effort efficient manner but we'd like to change that soon.

How are you going to do this?

We've adopted a strategy similar to Aspect Medical System's level of consciousness monitoring technology. We have designed a proprietary forehead electrode array along with signal processing and analysis that allows us to determine the patient's sleep state using the same electrophysiological criteria as traditional polysomnography. These electrodes are designed to be embedded in the PAP mask system so the patient can apply them with no extra effort. We are very focused on making this technology available directly and through OEM partnerships with PAP manufacturers and vendors.

What clinical trials have been performed?

We've been developing the recording and analysis technology

Visit us at Sleep 2007, Booth 515!

We are committed to being "Closer to our Customers", and that means listening to you and then providing the products needed to help make your sleep facility more successful. Many great things are happening at Embla... new hardware... new software... so many new things that you will have to see them to believe them.

Here are just a few examples... thank you.



Business Management Software Solutions

Thanks for Sharing.



Embletta® X100

Portable, Wireless, and Flexible PSG amplifier




embla®

CLOSER TO OUR CUSTOMERS™

Global Headquarters: 11001 W. 120th Ave., Broomfield, CO 80021 PH: 303.962.1800 or 888-662-7632
FX: 303.962.1810 www.embla.com www.shopembla.com

for some time including an informal trial with 75 patients. An independent research team at a local university teaching hospital is now in the data processing phase of a formal 100 patient study to validate the accuracy of this system. Future trials will focus on the effect of this technology on compliance and patient outcomes.

What are the benefits to the patient and physician?

The benefit to the patient is better therapy. If they have not received effective treatment there will be objective evidence to allow their physician to modify or supplement the therapy. The physician benefits by being able to provide real treatment, instead of just a prescription, which improves the quality of care they can offer. The patient will also have that feedback so they can be proactive about their treatment instead of just feeling guilty if it isn't working.

What are the benefits to the purchaser?

The purchaser has made a significant investment in a PAP system as well as the diagnostic testing to get them to that point. That's a worthwhile investment for the reduced long-term risks and improved alertness but only if the therapy is working. This system will ensure efficacy and improve compliance which is precisely the goal of the purchaser to begin with. We're especially interested in the savings of lives and dollars that will be achieved by reducing residual sleepiness which is known to lead to traffic accidents, lost productivity, and the like.

Embla

Kassandra Keller

Kassandra Keller is Director of Marketing for Embla.

What products do you offer for diagnostics? What are the latest trends for such products?

Embla is unique in that we offer the broadest range of sleep diagnostic products; from two channel screening devices to research level polysomnography and EEG amplifiers. All of these systems are integrated into our sophisticated, yet easy to use, sleep software platforms, Rembrandt and Somnologica.

The latest trends are efficiency and integration. We provide our customers with tools that assist them in streamlining their operation and helping them become more efficient. We do this with our Embla Enterprise software which integrates to the customers' HIS or laboratory management system. Enterprise facilitates electronic management of patient records, provides efficiency statistics, referral patterns and assists with Accreditation procedures.

What products do you offer for therapy? What are the latest trends for such products?

While Embla is focused solely on diagnostics, we appreciate that many of our customers are seeking both diagnostic and therapeutic solutions from a single vendor. We are proud to offer ResMed therapy products as part of our portfolio. Additionally, our systems are compatible with other manufacturers' therapeutic devices. The latest trends are related to treating Central Sleep Apnea in all its forms such as Complex Sleep Apnea or mixed sleep apnea. A unique approach is required to diagnose and treat these patients and we are excited to be part of the solution.

How has technology changed in the past several years?

Technology and the science of medicine are dynamic and exciting. These advances enable us to develop superior products with increased features. The devices continue to get smaller and smarter as we use innovation to combine unique tools for diagnosing and treating sleep disorders with lower cost manufacturing techniques.

Please discuss your company's current R&D efforts.

Embla is the global leader in sleep diagnostics. We are focused on our customers, asking them how we can continually improve our product lines to meet the changing needs of the marketplace. We are currently involved in software and hardware development that will give our customers new products to improve their operation and treat their patients. These efforts include the strategic integration and enhancement of our current sleep software platforms, a new wireless ambulatory PSG amplifier, and expansions to our Embletta product line.

How does your product deal with electronic records management?

Our Embla Enterprise system is an integrated business management solution designed to efficiently maintain and manage comprehensive patient records. Document management features facilitate electronic management of history & physical, patient questionnaires, patient data, follow up activities and more. Enterprise also interfaces to HIS or laboratory management systems via HL7 making electronic record management easy to achieve.

Please discuss your assistance programs and training programs for purchasers and/or patients.

Embla provides installation and training packages with all our systems to assure our customers are fully trained in its use. We also offer additional training tools that are excellent for continuing education and staff turnover.

What clinical trials have been performed on your device?

Embla has a rigorous quality system that includes both internal testing and verification, as well as, controlled releases that involve patients. Our systems have been utilized in numerous clinical trials in the US and across Europe many of which have been published.

What is the level of clinical evidence supporting the use of your device?

Embla devices are all CE & FDA approved for use in identifying and diagnosing sleep disorders. Many of our products, such as the Embletta for polygraphy are considered to be the gold standard.

Does your product have portable monitoring capability? If so, please discuss.

Many of our products are designed specifically for portable monitoring in a variety of settings. We offer screening devices to full portable polysomnography.

How can your product improve patient compliance?

From the diagnostic perspective, we provide clinicians with tools to easily show a patient the severity of their disorder and the clinical benefit of treatment. ResMed therapeutic products can provide reports on compliance and efficacy data. Clinicians can use this information to analyze usage trends and treatment efficacy.

The Perfect Portable Couple

ALL IMAGES ACTUAL SIZE



MediByte® • 10 Channels
Snoring & Apnea Screener



MediPalm® • 22 Channels
Full PSG Recorder

- Full PSG studies or screening, attended or unattended, portable or stationary configurations, with or without a computer!
- Two products developed by an industry leader in portable recording technology.

BRAEBON
For Today's Business of Sleep™

888-462-4841

braebon.com

How can your product improve patient outcomes?

The Embla Enterprise system allows clinicians to manage their patients from referral to follow up. This provides the tools needed to manage the patient outcomes.

Please discuss cost-savings/benefits for both purchasers and patients using your products.

We are dedicated to developing high quality products using the latest technologies. This allows us to provide our customers with a greater selection of products that in turn allow them to diagnose and treat more patients in a cost effective manner.

Braebon

Michael Clark

Michael Clark is Director of Marketing and Sales for Braebon.

What products do you offer for diagnostics?

Braebon offers a complete diagnostic line of products that include sensors, MediByte snoring and apnea screener, MediPalm full PSG system, and Pursuit Outcomes management software.

What are the latest trends for such products?

We believe the sleep testing market is moving towards more portable type recording environments. This could be testing in the home, hotels, nursing homes, hospital wards (ie, inpatients), truck drivers and other areas where more compact or portable equipment would be a benefit. Our MediByte screener and MediPalm PSG system are two products ideally suited for portable recording.

How has technology changed in the past several years?

Well, things are smaller and faster. What I mean is advances in electronic technology have allowed us to develop smart PSG recording amplifiers that include powerful microprocessors and lots of memory. This provides the opportunity to program these devices to operate in a number of configurations with or without a computer. As an example, our 10 channel MediByte screener weighs less than 3 ounces including battery and can be programmed a week in advance to record two back to back night studies. The MediPalm can be set up to record up to 22 channels for full PSG testing in either portable or stationary configurations. Both these products use advanced technology which provides the user with a high level of recording flexibility.

Please discuss your company's current R&D efforts.

Braebon invests a significant amount of revenue back into carefully selected R&D projects each year. In addition, as part of our ISO 13485 process all four product lines are constantly being improved to increase reliability and meet customer expectations. We are unique in that all products are developed and manufactured under one roof allowing us to ensure top quality control.

How does your product deal with electronic records management?

Our Pursuit Outcomes database software handles this requirement exceptionally well. This is effectively core management software that controls and tracks many aspects of a busy sleep testing facility. The centerpiece of this SQL database is the patient's electronic record with 22 sections of

information in a variety of formats. This includes demographics, insurance, physicians, questionnaires, sleep study results, scanned documents and images, diagnostic codes, patient history, medications and a number of other areas.

Please discuss your assistance programs and training programs for purchasers and/or patients.

Braebon has a variety of training programs for purchasers that include on-site or over the internet. Both the MediByte and MediPalm systems were designed to be so easy to learn and easy to use that in most cases all the configuration and training can be done over the web.

What clinical trials have been performed on your device?

The MediPalm and MediByte have been used in a number of hospital and private lab clinical trials. The most recent study was done by a large hospital based sleep lab that simultaneously compared the MediByte to the "gold standard" overnight PSG test. The results, to be published soon, clearly show our multi-channel screening device is an effective tool for detecting obstructive sleep apnea.

Does your product have portable monitoring capability?

Yes, both the 10 channel MediByte screener and 22 channel MediPalm have the best *performance per size ratio* on the market today. This means they have the most number of channels per square inch of enclosure size and are ideal for portable monitoring applications.

How can your product improve patient outcomes?

Our Pursuit Outcomes database tracks patients' outcomes in a variety of ways. In addition to CPAP compliance, a number of other important patient parameters such as medical history, sleep study results, therapy options and follow-up procedures are all tracked to ensure patients are able to receive the best treatment and service available.

Please discuss the cost-savings/benefits for both purchasers and patients using your products.

Braebon provides many of the most cost effective and extended warranted products available. As an example the MediPalm PSG system has a complete 3 year warranty. Our company mission is to provide quality, innovative alternatives in the field of sleep medicine.

Resmed

Michael Farrell

Michael Farrell is ResMed Vice President of Marketing, Americas.

What products do you offer for diagnostics? What are the latest trends for such products?

ResMed offers the first step in quality sleep patient management with the ApneaLink screening tool. The ApneaLink is a simple yet accurate way to screen potential OSA patients, guaranteeing that patients can be identified, triaged and diagnosed in the most efficient manner possible. A versatile tool, the ApneaLink can be used in the patient's home or any ambulatory setting; it simplifies and streamlines the sleep-screening process. The latest advance for ApneaLink is an integrated oximetry capability, adding pulse and pulse oximetry to AHI, flow limitation and snoring on its reports.



Simply amazing.

VPAP Adapt SV™: A Simply Amazing Solution for Complex Sleep Apnea



ResMed's Adapt SV technology has successfully treated thousands of patients suffering from complicated sleep-disordered breathing. To learn more about the only device that effectively treats complex sleep apnea and periodic breathing, visit www.resmed.com/simplyamazing.

"We've had patients continue to have high AHI with central events, despite our best efforts to titrate with CPAP and bilevel. With these complex patients, VPAP Adapt SV effectively normalizes breathing where the other therapies have failed. It makes our lives easier because our patients' lives are improved. I'm very impressed with it."

— **Dr. Bruce Corser, Sleep Management Institute**

RESMED

1-800-424-0737

What products do you offer for therapy? What are the latest trends for such products?

We offer a wide range of products for the screening, treatment and management of sleep-disordered breathing. Our award-winning product line covers all aspects of the SDB treatment spectrum, including continuous positive airway pressure (CPAP), automatic positive airway pressure (APAP) and bilevel positive airway pressure. We also offer a range of humidification products, nasal interface systems and accessories, screening tools and clinical systems. Positive airway pressure (PAP) treatment has come a long way since its invention in 1981, with a shift toward consumer-friendly products packed with more features to ensure comfortable therapy for patients as well as adherence and outcome data for clinicians. Even the size of therapy products has changed over the past couple of years, with the introduction of more compact and lightweight devices, like ResMed's S8 series of flow generators and our Mirage Swift™ II nasal pillows system. Now more than ever, these lifestyle-oriented products are designed with the patient in mind to improve comfort and increase compliance.

How has technology changed in the past several years?

Advances in technology have allowed us to treat a broader range of patients more comfortably and effectively than ever before. Our masks and flow generators are designed for every type of sleeper and every type of nocturnal breathing disorder. For example, the adaptive servo-ventilation algorithm in ResMed's VPAP Adapt SV device treats patients with complex sleep apnea where other technologies have failed. ResMed's EPR technology provides a way to improve patient compliance without compromising therapy effectiveness by lowering pressure upon exhalation so that breathing feels more natural. EPR offers three comfort settings in addition to other built-in controls so clinicians can reliably manage expiratory pressure relief therapy.

Please discuss your company's current R&D efforts.

We invest approximately 6-7% of revenues in research and development efforts, which is a growing dollar figure every year. ResMed's team is focused on developing innovative therapies for SDB that enhance patient comfort and convenience while improving health. We interact directly with customers on a daily basis through our field clinical and sales force, and our marketing team ensures that the customer's voice actively drives our product development process. ResMed is constantly looking for ways to improve our products to benefit both our customers who distribute them and our patients who use them. Our products for the pediatric sleep apnea market, the Mirage Kidsta and VPAP III ST-A, are an example of ResMed putting the needs of children and their parents at the top of our development list.

How does your product deal with electronic records management?

With Boomerang Access, ResMed offers a comprehensive tool that is effective for efficiently managing a few patients to a few thousand patients. Boomerang Access helps users manage compliance and replacement schedules with multiple patient reminders, auto-generated notes and forms and management reports. Boomerang Access is a powerful, efficient and user-friendly data management system designed specifically for organizations that dispense equipment and supplies for the treatment of SDB.

Please discuss your assistance programs and training programs for purchasers and/or patients.

ResMed's Clinical Education team is made up of a dedicated group of respiratory technicians and registered sleep technologists with extensive backgrounds in both cardiopulmonary and sleep medicine. The team works with our sales representatives to assist hospitals, sleep centers and sleep

THE NEXT GENERATION
IN SENSOR TECHNOLOGY...

(Polyvinylidene fluoride)

- Reach AHI sooner
- Consistent Oral and Nasal airflow detection
- No cannula or transducer box required
- More accurate than air pressure transducer¹
- Compares with a pneumotach²
- Compares with an esophageal balloon³

Dymedix
dynamic medical technology

PHONE 888-212-1100
FAX 763-781-4120
www.dymedix.com

1 Todd Elken, RPSGT- Sleep Review™ Sept. 2005
2 Richard Berry, MD- CHEST Sept. 2005
3 William Orr, PhD- APSS 2003

labs with their educational needs. We offer specific training in ventilation, titration techniques and diagnostic procedures, with the opportunity for providing continuing education units (CEUs) to respiratory therapists, nurses, registered sleep technicians and case managers. We also have a team of technical experts as part of our Customer Service team who assist our customers with day-to-day queries, from product support to clinical questions. Our Reimbursement Hotline is also available for customers who have questions regarding insurance guidelines and procedures. In addition, we offer multiple online resources, including therapy tips for CPAP patients at MyResMed.com, information for undiagnosed sleep apnea patients at HealthySleep.com, and information for clinicians regarding the VPAP Adapt SV at www.resmed.com/SimplyAmazing.

What clinical trials have been performed on your device?

Clinical trials comparing the adaptive servo-ventilation algorithm of the VPAP Adapt SV to other treatment modalities have been performed in regions around the world, including the United States, Europe and Asia. These studies have compared the effectiveness of the Adapt SV technology versus continuous positive airway pressure (CPAP), bilevel and oxygen therapy in treating central sleep apnea. These studies show that the Adapt SV technology outperforms other modes of treatment in resolving a range of obstructive and central apneic events, restoring slow-wave sleep and reducing arousals. A study conducted by Philippe also showed improvement in quality of life measures and left ventricular ejection fraction in patients with heart failure on Adapt SV therapy. The following studies reference the effectiveness of the adaptive servo-ventilation algorithm:

- 1 Philippe et al. Compliance with and effectiveness of adaptive servo-ventilation versus continuous positive airway pressure in the treatment of Cheyne-Stokes respiration in heart failure over a six month period. *Heart* 2006;92:337-342
- 2 Teschler et al. Adaptive pressure support servo-ventilation: A novel treatment for Cheyne-Stokes respiration in heart failure. *Am J Respir Crit Care Med* 2001;164:614-619.
- 3 Banno K, Okamura K, Kryger MH. Adaptive servo-ventilation in patients with idiopathic Cheyne-Stokes breathing. *J Clin Sleep Med* 2006;2(2):181-186.
- 4 Pepperell et al. A randomized controlled trial of adaptive ventilation for Cheyne-Stokes breathing in heart failure. *Am J Respir Crit Care Med* 2003;168:1109-1114.
- 5 Zhang et al. Efficacy of adaptive servo-ventilation in patients with congestive heart failure and Cheyne-Stokes respiration. *Chin Med J* 2006;119(8):622-627.
- 6 Hanly PJ and Zuberi-Khokhar NS. Increased mortality associated with Cheyne-Stokes respiration in patients with congestive heart failure. *Am J Respir Crit Care Med* 1996;153:272-276.

What is the level of clinical evidence supporting the use of your device?

Peer-reviewed literature published over the last seven years shows that the algorithm in ResMed's VPAP Adapt SV normalizes breathing, completely suppressing central sleep apnea and/or Cheyne-Stokes respiration in heart failure patients.^{1,2} It also improves sleep architecture¹ (increases the amount of time the patient spends in slow-wave and REM sleep) and enhances quality of life.^{2,3} In addition to the clinical trials listed above, ResMed's adaptive servo-ventilation therapy has been used successfully on thousands of patients around the world for millions of treatment hours. The clinical results with the Adapt SV have been consistently and overwhelmingly positive.

Does your product have portable monitoring capability? If so, please discuss.

Data stored on the VPAP Adapt SV can be viewed on a PC via ResScan software, which allows users to view, assess and report therapy information. In addition, the ResLink module with oximetry captures in-depth data and monitors oxygen saturation. In addition, ResMed's S8 AutoSet Vantage, S8 Elite, VPAP III and VPAP III ST have wireless, internet-enabled monitoring systems for remote monitoring. ResTraxx technology will work in a truck, at a hotel or in the home – it moves with the patient, allowing tracking of adherence and efficacy data.

How can your product improve patient compliance?

VPAP Adapt SV ensures that pressure support is synchronized to the patient's own recent breathing rate and flow pattern. It provides constant, low pressure support to maximize patient comfort and compliance. And, unlike traditional bilevel therapy, VPAP Adapt SV delivers a smooth pressure waveform, which is similar to natural breathing. Additionally, the optional integrated humidifier improves comfort by relieving the symptoms that are associated with CPAP therapy.

How can your product improve patient outcomes?

The VPAP Adapt SV is the first and only device cleared for the treatment of central sleep apnea (CSA), mixed sleep apnea and periodic breathing such as Cheyne-Stokes respiration (CSR) in both hospital and homecare environments. By providing this

Do YOU stand out in a crowd?




SIGN-ON BONUSES OF UP TO \$10,000 POSSIBLE

SleepTech, LLC is the largest provider of sleep diagnostic partnership services in the NY metro area. We currently have opportunities for entry-level or experienced sleep technologists in Northern NJ, Southwestern CT and the Lower Hudson Valley, NY areas.

- Excellent hourly rates
- A-STEP training and clinical continuing education for CEC
- Benefits include 401(k) and mileage reimbursement

For more information or to submit interest:
careers@sleeptech.com • Fax: (973) 850-7123


www.sleeptech.com

revolutionary therapy, the VPAP Adapt SV is able to deliver amazing results and superior patient outcomes where other therapies have failed.

Please discuss cost-savings/benefits for both purchasers and patients using your products.

Unlike conventional SDB therapies such as CPAP, the VPAP Adapt SV device treats central sleep apnea in all its forms to provide the right therapy the first time. Patients with complex sleep apnea cannot be adequately treated with CPAP, but the proven track record of the VPAP Adapt SV ensures a simple and effective solution for these complex breathing disorders.

Clinicians benefit from this revolutionary device that treats these patients where other technologies have failed. The default settings on the VPAP Adapt SV are suitable for most patients, so titrating patients is a simple process for sleep lab technicians. Most importantly, patients benefit from the effective therapy that the VPAP Adapt SV delivers. As a result their lives are improved and they can finally get a good night's sleep. Visit resmed.com/SimplyAmazing for further information.

Clevemed

Hani Kayyali

Hani Kayyali is President of CleveMed (Cleveland Medical).

What products do you offer for diagnostics?

Crystal Monitor 20-S and Crystal Monitor 20-B are small, handheld, 14-channel wireless PSG systems that come with two different data transmission frequencies. With different frequency options, sleep labs are able to choose the system best suited for their environment.

Sapphire PSG is a 22-channel wireless PSG system that offers full PSG diagnostic capabilities in a small and flexible package. With multiple wireless data transmission frequency options built into the hardware and software, the Sapphire PSG offers the flexibility to be used in hospitals, even in critical care areas, as well as sleep labs, patient homes and international markets. SleepScout is a small and compact 9-channel screener for sleep-disordered breathing or restless leg syndrome. Unlike other sleep screeners, SleepScout is designed with an onboard wireless data transmitter that can communicate with a PDA or laptop computer to confirm proper electrode placement. In addition to the 7 dedicated channels, SleepScout's flexible design offers an additional 2 channels that are fully programmable in which the technician can acquire any combination of EEG, EOG, ECG and EMG. Data is stored on a removable memory card for later retrieval. Each system includes a sophisticated PSG software package and a flexible, wireless design that allows for attended, virtually attended, and unattended studies in almost any setting.

What are the latest trends for such products?

The latest trend in diagnostic products is Wireless. Sleep disorders, especially sleep disordered breathing (SDB), is no longer an isolated disorder. It is strongly linked and can impact the management of care of many life threatening diseases like cardiovascular and pulmonary diseases. Undiagnosed SDB can also complicate surgeries and can play a role in caring for the elderly. It is not reasonable to ask all these patients to come to the sleep lab for diagnosis; labs are overcrowded as it is. In

order to properly diagnose these patients, we must go to them, whether it is in the hospital room, surgical suite, nursing home or their own home. This is where wireless comes in. Just like the way cell phones changed the communication industry, wireless PSG will change the sleep diagnosis market by quickly reaching those patients wherever they are and when they most need it.

What products do you offer for therapy? What are the latest trends for such products?

We are currently working on a new CPAP device that has vastly improved diagnostic capability. We can not say much about our new technology at this point because it is confidential, but we believe that new applications will fuel CPAP's growth. Whether using CPAP postoperatively to reduce surgical complications, or whether it monitors subtle and serious changes in the patient's disease state over time, CPAP technology must step up to meet these new needs. One example is Complex Sleep Apnea. Research is finding that up to 15% of the current CPAP users may in fact be developing Central Sleep Apnea, which will likely need different treatment. Current CPAP machines can not detect those changes, and therefore cannot properly report on the progress of potentially thousands of patients! Who knows what new disease states we will find in the near future that demand careful therapy management. Therefore, future therapeutic products are those that are smarter with capabilities to offer effective therapy for the complicated patient who is becoming the norm and not the exception. As importantly, these technologies must be developed for home use since pressures to shift diagnosis and treatment from the lab to the home continue to mount.

How has technology changed in the past several years?

While advancements in oral appliance technologies and surgeries have improved, CPAP continues to be the most effective and popular sleep apnea therapy. However, as mentioned earlier, traditional CPAP is no longer sufficient. I believe the traditional CPAP market will slowly but surely be replaced with smarter CPAP technologies. Indeed, several benchmark studies have shown improvement in Auto-Adjust CPAP technologies over the past couple of years. There is a lot more work to do in this area, especially since SDB is a relatively young disease with new clinical manifestations and comorbidities that continue to be uncovered regularly.

Please discuss your company's current R&D efforts.

CleveMed's R&D efforts have been focused on finding new and innovative technologies for both the diagnosis and treatment of sleep disorders. Our current product offerings include the Crystal Monitor 20-S and Crystal Monitor 20-B, complete wireless 14 channel PSG systems and SleepScout, a 9 channel sleep disorders screener. To help physicians find the system best suited for their environment, CleveMed will be releasing Sapphire, a 22 channel wireless PSG system, in June of this year. All four systems include Crystal PSG software, a sophisticated software package for data acquisition, scoring and reporting. Later this year, the software will be expanded to include scoring for neonatal sleep studies. CleveMed's R&D for sleep disorders diagnosis has been focused on expanding the reach of the sleep lab to include other settings such as hospital patient rooms, outpatient pre-surgical centers, nursing homes, "sleep hotels" and patients' homes. In doing so, physicians and technologists who need flexibility because of different service contracts benefit from our systems, as do patients that are better suited to

testing outside of the sleep lab, such as pre-surgical patients, children and those that are less mobile. To complement our products in these settings, CleveMed will be releasing two new proprietary medical communication systems for the hospital inpatient setting and the patient's home. These systems will allow for attended, virtually attended, and unattended studies. In addition to the up and coming line of diagnostic products currently under development, CleveMed is heavily involved in R&D for a new line of CPAP products.

How does your product deal with electronic records management?

We work directly with customer sites and offer HL7 integration. In addition, our systems include a built-in patient database and record storage and archival capabilities. To help organizations comply with HIPAA regulations, our systems offer security features such as data encryption and access control.

Please discuss your assistance programs and training programs for purchasers and/or patients.

We offer on-site technologist training, additional web-based training, 24/7 technical support and on-staff clinical specialists. Loaner units are provided at no cost during the warranty period as needed to eliminate downtime.

What clinical trials have been performed on your device?

Our PSG systems have been validated in clinical trials against other commercial sleep systems, resulting in similar diagnostic outcomes on both systems. Currently clinical trials are taking place using our sleep systems for testing hospital inpatients and home testing. Our wireless systems combined with intranet or internet connections allow for testing to be virtually attended from nearly anywhere.

What is the level of clinical evidence supporting the use of your device?

Clinical evidence has been well established for diagnostic sleep testing. Our products make sleep testing more convenient for the patient and sleep technologist by allowing the study to take place anywhere. This is particularly important for patient populations that may be difficult to test in a lab such as pediatrics, inpatients and the elderly.

Does your product have portable monitoring capability? If so, please discuss.

Our Crystal Monitor PSG Series and upcoming Sapphire PSG integrate the headbox, amplifiers, transducers and data telemetry into one small, handheld patient unit that transmits the data wirelessly to a computer unit attached to a PC up to 100 feet away. Because of the systems' wireless design, time consuming and costly hard-wiring is eliminated, allowing for fast, simple and cost-effective system setup and rearrangement in any setting. Additional technology options for these products include the ability to perform virtually attended PSG studies, in which the sleep technician can monitor the patient's PSG signals and video live from almost any location, regardless of distance from the patient. Multiple wireless operating frequency options also help to make the systems suitable for almost any setting, including Bluetooth based radios, hospital specific frequencies (WMTS) and more.

CleveMed also offers SleepScout, a 9-channel wireless sleep screener with a removable memory card. The simple and compact design allows for preliminary assessment of sleep

disordered breathing to be made outside of the traditional sleep lab, such as in a patient's home or in a hospital setting.

How can your product improve patient outcomes?

Our products can help a sleep lab test patients sooner. By testing patients sooner to correctly diagnose the patient they can begin treatment sooner, which will improve outcome.

Please discuss cost-savings/benefits for both purchasers and patients using your products.

Both patients and purchasers benefit from our products' flexibility, wireless design and competitive pricing. Our suite of products range from a 22 channel full PSG system to 14 channel PSG systems to a sleep screener, and we offer proprietary technology to allow the lab to perform attended, virtually attended or unattended studies. In other words, patients can be tested in the setting most suitable to their personal situation, and sleep labs are able to select from a variety of products and setting options, giving them the ability to readily expand their reach to non-traditional settings and fulfill new needs. Patients also benefit from the systems' wireless design in increased comfort and mobility. In addition, CleveMed's pricing is extremely competitive considering the high quality proprietary technologies, patented wireless design, high reliability, and compact size.

EXECUTIVE PROFILE

Teleflex Medical

Christianna Vance

Christianna Vance is Sleep Therapy Product manager, Teleflex Medical.

Teleflex Medical is a global organization dedicated to supporting healthcare providers with a broad range of medical solutions. With a history of providing quality products, our brands have a reputation for excellence that spans nearly two hundred years. With our entry into the Sleep Therapy Market, Teleflex Medical is focused on providing breakthrough CPAP interfaces that help clinicians overcome the challenges presented by traditional masks: patient comfort and oral leaks.

By offering cutting edge, innovative solutions to meet the needs of the sleep apnea patient, we are proud to introduce the Hybrid CPAP Mask. The Hybrid is a unique fusion of technologies, designed to be a universal interface for patients and clinicians. The Hybrid is a dual-airway interface that consists of an oral cushion that covers the mouth and two nasal pillows that fit into the patients nostrils.

The Hybrid technology is ideal for patients who experience claustrophobia during therapy by minimizing the multiple points of contact on the face. The Hybrid eliminates the problems commonly associated with full face masks: skin breakdown on the nose and forehead, patient comfort and claustrophobia. The Hybrid promotes superior patient care by providing a more comfortable fit for the patient while allowing them to wear glasses as needed.

Teleflex Medical utilizes the Voice of Customer Process to truly

understand the needs of patients and clinicians. In market surveys we found that both clinicians and patients identified oral leaks as one of the most difficult side effects encountered during CPAP therapy. Because the Hybrid is the only dual-airway design that addresses oral leaks, while at the same time increasing patient comfort, this is the mask of choice for a wide range of CPAP patients.

We stay close to the CPAP community through organizations like Talk About Sleep and cpaptalk.com. Through these chat forums we are able identify our customers' needs and make appropriate design changes. This was extremely effective in the redesign of the Hybrid Headgear. We made the headgear more robust with 6 points of adjustability providing the patient a more comfortable, custom fit.

Teleflex Medical views the clinician as a vital part of the product design process. We look to clinicians to provide feedback in order to make changes and improvements to our entire respiratory line. We are dedicated to supporting healthcare providers by developing innovative solutions that truly make a difference today, tomorrow and for years to come. Contact teleflexmedical.com.

- 1 Teschler H et al. Am J Respir Crit Care Med. 2001; 164: 614–19
- 2 Philippe C. Heart. 2005; Published online Jun 20
- 3 Töpfer V et al. Pneumologie. 2004; 58(i): 28–32

Depression and Obstructive Sleep Apnea

Carmen M. Schröder, Ruth O'Hara

Abstract

For over two decades clinical studies have been conducted which suggest the existence of a relationship between depression and Obstructive Sleep Apnea (OSA). Recently, Ohayon underscored the evidence for a link between these two disorders in the general population, showing that 800 out of 100,000 individuals had both, a breathing-related sleep disorder and a major depressive disorder, with up to 20% of the subjects presenting with one of these disorders also having the other. In some populations, depending on age, gender and other demographic and health characteristics, the prevalence of both disorders may be even higher: OSA may affect more than 50% of individuals over the age of 65, and significant depressive symptoms may be present in as many as 26% of a community-dwelling population of older adults.

In clinical practice, the presence of depressive symptomatology is often considered in patients with OSA, and may be accounted for and followed-up when considering treatment approaches and response to treatment. On the other hand, sleep problems and specifically OSA are rarely assessed on a regular basis in patients with a depressive disorder. However, OSA might not only be associated with a depressive syndrome, but its presence may also be responsible for failure to respond to appropriate pharmacological treatment. Furthermore, an undiagnosed OSA might be exacerbated by adjunct treatments to antidepressant medications, such as benzodiazepines.

Increased awareness of the relationship between depression and OSA might significantly improve diagnostic accuracy as well as treatment outcome for both disorders. In this review, we will summarize important findings in the current literature regarding the association between depression and OSA, and the

possible mechanisms by which both disorders interact. Implications for clinical practice will be discussed.

Depression in OSA

Definition and prevalence of OSA: OSA is by far the most common form of sleep disordered breathing and is defined by frequent episodes of obstructed breathing during sleep. Specifically, it is characterized by sleep-related decreases (hypopneas) or pauses (apneas) in respiration. An obstructive apnea is defined as at least 10 seconds interruption of oronasal airflow, corresponding to a complete obstruction of the upper airways, despite continuous chest and abdominal movements, and associated with a decrease in oxygen saturation and/or arousals from sleep. An obstructive hypopnea is defined as at least 10 seconds of partial obstruction of the upper airways, resulting in an at least 50% decrease in oronasal airflow.

Clinically OSA is suspected when a patient presents with both snoring and excessive daytime sleepiness (EDS).^{1,2} The diagnosis of OSA is confirmed when a polysomnography recording determines an Apnea-Hypopnea-Index (AHI) of > 5 per hour of sleep.³ Even if cutoff points have never been clearly defined, an AHI of less than 5 is generally considered being normal, 5–15 mild, 15–30 moderate and over 30 severe OSA.

The prevalence of OSA is higher in men than in women. OSA is found in all age groups but its prevalence increases with age. In children, the prevalence of OSA is less well defined and has been estimated to be 2–8%.⁴ In subjects between the ages of 30 to 65 years, 24% of men and 9% of women had OSA.⁵ Among subjects over 55 years of age, 30–60% fulfill the criterion of an AHI > 5.^{6–8} In a population of community-dwelling older adults, 70% of men and 56% of women between the ages of 65 to 99 years have evidence of OSA with a criterion of AHI > 10.⁹

The abnormal respiratory events which are the hallmark of OSA are generally accompanied by heart rate variability and arousals from sleep, with frequent arousals being the most important factor resulting in EDS. With regards to sleep architecture, we find a significant increase in light sleep stage (mainly stage 1) at

The authors are with the Department of Psychiatry and Behavioral Sciences, Stanford University School of Medicine, Stanford, CA. Reprinted from BioMed Central, *Annals of General Psychiatry*, © 2005 Schröder and O'Hara; licensee BioMed Central Ltd. This is an Open Access article distributed under the terms of the Creative Commons Attribution License.

the expense of deep slow wave sleep (stages 3 and 4) and REM sleep. Slow wave sleep is sometimes even completely abolished. However clinically, patients are often not aware of this repetitive sleep interruption (with sometimes hundreds of arousals during one night), but simply do not feel restored in the morning. Other nocturnal symptoms can include restlessness, nocturia, excessive salivation and sweating, gastroesophageal reflux, as well as headache and dry mouth or throat in the morning on awakening.

The extent to which daytime functioning is affected generally depends on the severity of OSA. Symptoms other than EDS which greatly impact daytime functioning are neuropsychological symptoms such as irritability, difficulty concentrating, cognitive impairment, depressive symptoms, and other psychological disturbances. Thus, OSA can easily mimic symptoms of a major depressive episode.

Correlation studies of OSA and depression

Among the first studies investigating the relation between OSA and depression, Guilleminault et al.¹⁰ reported that 24% of 25 male patients with OSA had previously seen a psychiatrist for anxiety or depression, and Reynolds et al.¹¹ showed that around 40% of 25 male OSA patients met the research diagnostic criteria for an affective disorder, with a higher risk of depression in those patients who were sleepier during the day. Similarly, Millmann et al. observed that 45% of his 55 OSA patients had depressive symptoms on the Zung Self-Rating Depression Scale, with the group scoring higher for depression also having a significantly higher AHI.¹² Whereas only 26% of OSA patients described themselves as currently depressed, 58% fulfilled DSM-III criteria for major depression of four or more depressive symptoms.¹³ Others observed increased depression scores on the Minnesota Multiphasic Personality Inventory (MMPI) in patients with OSA.^{14,15} Indeed, Ramos Platon et al. found elevations in several MMPI scales in 23 OSA patients (moderate to high severity) compared to 17 controls.¹⁶ Aikens et al.¹⁷ showed that 32% of their OSA patients had elevated depression scores on the MMPI and in the same series of studies, there were twice as many OSA patients with elevated depression scores than age and sex matched primary snorers.¹⁸ However, the percentage of depressive symptoms was not significantly different when compared to patients with other primary sleep disorders, such as periodic limb movements during sleep (PLMS).¹⁹ Most recently, in an epidemiological study of 18,980 subjects representative of the general population in their respective countries (UK, Germany, Italy, Portugal, and Spain) and assessed by cross-sectional telephone survey, Ohayon determined that 17.6% of subjects with a DSM-IV breathing-related sleep disorder diagnosis also presented with a major depressive disorder diagnosis, and vice versa.²⁰ This correlation persisted after controlling for obesity and hypertension.

In contrast to the numerous studies observing a positive correlation between OSA and depression, some investigations found no association between both disorders. In a 5-year longitudinal study, Phillips et al. did not find any significant depressive symptoms in elderly patients with a relatively mild OSA (AHI > 5/h), when compared to a control group without OSA (AHI < 5/h).²¹ However, there are multiple limitations to this study, besides a relatively small sample size for group comparisons and a non-representative study population. OSA was only assessed at baseline, but not repeated at the five-year follow-up, i.e. neuropsychological data were compared between

two groups based on OSA status five years earlier. Second, OSA severity was mild even in the OSA group. Third, the groups differed significantly by age, with the OSA group being older than the control group. Finally, the attrition rate over the five years was very high with only 42 out of the initial 95 subjects completing the follow-up assessment. In another large-scale study, Pillar and Lavie did not observe any association between respiratory disturbances and Symptom Check List 90 in 2,271 predominantly male patients assessed for OSA.²² However, the SCL-90 questionnaire was developed as a screening tool for psychiatric patients, and not for a normal study population. Therefore, it might be a less sensitive tool with regards to milder forms of mood disturbances than other scales. Interestingly, Pillar and Lavie observed that among the minority of women in this study, those with severe OSA had higher depression scores than those with mild OSA. Bardwell found that other factors such as age, body mass index (BMI) and hypertension accounted for the correlation between sleep parameters and total mood disturbances in 72 OSA patients when compared to 40 controls.²³ However, the chosen cutoff point to distinguish between OSA and the control group in this study was relatively high (AHI of 15/h), thus subjects with a mild OSA were probably included in the control group.

In sum, the majority of studies to date report an association between depression and OSA, but methodological considerations render the comparison between investigations difficult. Some of the mixed findings among studies can be explained by differences in sample size, study population, gender distribution, age and AHI cut-off in relation to age, as well as variability in terms of the questionnaires and scales used to assess depressive symptomatology. Given the heterogeneity of these data and considering the numerous confounding factors, future longitudinal studies of patient populations are required to better understand the relation between both disorders.

Treatment studies for OSA: reversibility of depressive symptoms?

The gold standard treatment for moderate to severe cases of OSA is continuous or bilevel positive airway pressure (CPAP/BiPAP) which mechanically maintains the upper airways space open during sleep via the administration of ambient air with a certain pressure. The minimum necessary pressure level has to be titrated individually for each patient.²⁴ Other treatments, especially for mild cases of OSA, include weight loss, dental devices (which advance the tongue or mandible to increase posterior airway space) or upper airway surgery (e.g. combined tonsillectomy/adenoidectomy, nasal reconstruction, and uvulopalatopharyngoplasty). Different upper airway surgical procedures can be used for particular cases with craniofacial abnormalities.²⁵

Overall, CPAP treatment studies for OSA and its effect on depressive symptoms have yielded controversial findings. Derderian et al.²⁶ compared results on the Profile of Moods Questionnaire before and after 2 months of CPAP treatment in an OSA group (n = 7) and showed a significant drop in Total Mood Disturbance. This improvement was correlated with an increase in slow-wave sleep. Those patients in the study of Millmann et al. who received CPAP displayed a significant decrease in their Zung Depression Scale scores.¹² Similarly, Engleman et al. reported an improvement in a comprehensive battery of mood and cognitive assessment scales after 4 weeks

of CPAP treatment in 32 patients with moderate OSA²⁷ as well as in 16 patients with a mild OSA.²⁸ Means et al.²⁹ showed an improvement on Beck Depression Inventory (BDI) depression scores after 3 months of treatment in 39 OSA patients, and Sanchez et al.³⁰ confirmed lower BDI scores after 1 and 3 months of CPAP therapy in 51 OSA patients. Ramos Platon et al.¹⁶ underscored the progressive improvement in depression scores on the MMPI scale over the first year of treatment. A systematic review on the influence of CPAP on neurobehavioral performance of patients with OSA also supported the clinical perspective that typically depressive symptoms remit together with EDS under CPAP therapy.³¹

Among the negative studies on CPAP therapy and its effect on depression, Borak et al.³² did not observe any improvement in emotional status after 3 and 12 months of CPAP therapy in 20 patients with severe OSA, similar to Munoz et al.³³ who also did not show improvement of BDI scores in 80 subjects with severe OSA after 12 months of CPAP. Using subtherapeutic CPAP as the placebo control, Yu et al.³⁴ and Henke et al.³⁵ found no difference in improvement on depression scores between the treatment and the control group, over a short treatment duration (1–3 weeks). However, whereas Borak, Munoz and Henke do not find any effect of CPAP therapy on mood, Yu observed a positive effect on mood of both CPAP therapy and the subtherapeutic CPAP control group.

Intriguingly, there are no systematic differences with regards to the sample size, the initial severity of OSA or the duration of CPAP therapy which might explain the differences between studies observing an improvement after CPAP therapy and those who did not. Several issues have to be considered: First, it is difficult to design a good control (“placebo”) condition for CPAP treatment. “Sham-CPAP” which uses insufficient positive airway pressure as a placebo condition (1 – 2 cm H₂O), is now used more frequently. Two of the negative studies employed this method for their control group, which raises the possibility that the previously observed positive effects of CPAP on mood may have been a placebo effect. Second, compliance to CPAP treatment is problematic, because patients have to wear a nasal or even an oronasal device during the entire night. The compliance may even be particularly decreased in depressed patients. Indeed, Edinger et al.³⁶ reported a positive correlation between lower depression scores on the MMPI prior to treatment and CPAP compliance at 6 months of treatment in 28 patients. However, Lewis et al.³⁷ did not find any association between baseline depression scores and subsequent CPAP use for the first month of treatment. The most important factor to explain the differences among these studies may be the variability in the severity of initial depressive symptoms. Whereas the severity of OSA itself does not seem to have a differential impact on mood improvement after CPAP therapy, the severity of depressive symptoms associated with OSA may impact response to CPAP treatment. As Millmann indicates, OSA patients with more severe mood symptoms responded better to CPAP treatment, whereas patients with less severe or no mood symptoms actually had less benefit from CPAP therapy.¹² However, all negative treatment studies either excluded subjects suffering from a major depressive disorder, or their depression scores were even at baseline in a normal range (baseline values: mean BDI of 7.5 in,³² mean depression score on POMS scale of 12.5 in,³⁴ mean BDI of 8 in,³³ and no information given on assessed GDS scores in³⁵). Future studies should seek to include OSA patients with a broader range of depressive

symptoms in treatment studies, to investigate whether CPAP might have a better effect on mood in more depressed OSA patients.

OSA in depression

Compared to the large number of studies investigating depressive symptomatology in OSA patients, far fewer studies have focused on the screening for OSA in a primarily depressed study population. In one of the few investigations of the prevalence of OSA in a depressed cohort, Reynolds et al. found, in a small sample of 17 older patients with major depression, that 17.6% also had an OSA syndrome, compared to 4.3% of 23 healthy elderly controls.³⁸ This suggests that OSA might be an important confounding factor for studies on mood disorders in general, as its presence is not routinely determined in either research studies examining mood or clinical settings. However, many more studies are required to assess the prevalence of OSA in primarily depressed patients, particularly as it can be suspected from existing studies that OSA is greatly underdiagnosed in this patient population.

Clinically, this is of particular concern, as sedative antidepressants and adjunct treatments for depression may actually exacerbate OSA. Notably hypnotics prescribed to treat depression-related insomnia might further decrease the muscle tone in the already functionally impaired upper airway dilator muscles, blunt the arousal response to hypoxia and hypercapnia as well as increase the arousal threshold for the apneic event, therefore increasing the number and duration of apneas.^{39,40} These effects might differ depending on the patient population and the severity of OSA. Older depressive subjects are of primary concern: both, frequency of OSA and depressive symptoms increase with age, as do prescription and consumption of sedative psychotropic medication. Pharmacologic treatment of depression and depression-related insomnia in this age group should therefore routinely consider the potential presence of a concomitant OSA.

Finally, as Baran and Richert point out, the diagnosis of a mood disorder in the presence of OSA has its very own challenges.⁴¹ Considering the DSM-IV definitions,⁴² it could either be viewed as a mood disorder due to a general medical condition, or classified as an adjustment disorder with depressed mood, due in particular to EDS and its debilitating consequences on the patients’ daytime functioning. The identification of pathophysiological features that allow distinction between OSA and depression might assist with such diagnostic issues.

Sleep architecture in depression and OSA

Both depression and OSA have been well characterized with regards to their sleep architecture. Typically, for major depression, polysomnography (PSG) findings confirm the patients’ complaints of insomnia, notably difficulties falling asleep (PSG: increase in sleep latency), frequent awakenings during the night and early morning awakenings (PSG: idem) as well as non-refreshing sleep (PSG: decrease in slow wave sleep). PSG furthermore reveals a shortened REM latency, i.e. the first episode of REM sleep appears earlier than usual, with an increase in total percentage of REM sleep during the night, as well as in its eye movement density (referred to as REM sleep disinhibition).⁴³ On the other hand, the sleep of patients with OSA is fragmented, and contains a lot of transitional sleep stages (stage 1) at the expense of REM sleep and particularly of slow wave sleep (stages 3 and 4).^{44,45} At least two studies have

investigated sleep architecture at the interplay of OSA and depression or depressive symptoms. Reynolds et al. stated that, in contrast to the sleep EEG of depressed patients which characteristically shows a shorter latency of REM sleep, sleep apnea patients with depression displayed an increase in REM latency.¹¹ Bardwell et al. compared a group of 106 patients with and without OSA with regards to their sleep architecture. Depressed patients who also had OSA displayed a decrease in sleep latency when compared to the depressed group without OSA; and OSA subjects with depressive symptoms had a higher percentage of REM sleep than OSA subjects without depression.⁴⁶ Rather than distinguishing a primary depressive illness from an organic affective syndrome related to OSA,¹¹ however, the aforementioned polysomnographic results underscore how both disorders interplay, thus confounding EEG findings characteristic for each disorder.

Possible mechanisms underlying the association between depression and OSA

Sleep fragmentation and hypoxemia: The two main factors suspected to be responsible for depressive symptoms in OSA are sleep fragmentation and oxygen desaturation during sleep. Sleep fragmentation is a direct consequence of the recurrent microarousals associated with the apneas and hypopneas, and the nocturnal hypoxemia is due to the intermittent drops in oxygen saturation caused by the respiratory events.⁴⁷ Sleep fragmentation is the primary cause of EDS in OSA patients, and is suggested to result in the depressive symptomatology in OSA. This last perspective gains support from the finding that EDS as measured by the Epworth Sleepiness Scale (ESS) and the Maintenance of Wakefulness Test (MWT) was found to be correlated with higher depression scores on the Hospital Depression Scale (HAD-D) in 44 patients with OSA.⁴⁸

Furthermore, a Canadian study on 30 OSA patients showed a significant correlation between the severity of psychological symptoms on SCL-90 and less total sleep time, as well as percentage of wake time after sleep onset and ESS scores.⁴⁹ With respect to hypoxemia, Engleman et al noted in a recent review that the effect size of cognitive impairment in OSA correlated highly with severity of hypoxic events, ranging from .3 standard deviations for milder levels of AHI to 2–3 standard deviations for higher levels of AHI.⁵⁰ Recently, preliminary imaging data suggests that hypoxemia related to OSA might also play a role in impacting mood. Cerebral metabolic impairment resulting from recurrent nocturnal hypoxemia in OSA have previously been observed in several imaging investigations on OSA,^{51–53} independently, white matter hyperintensities (WMH) have been linked to depressive symptomatology in studies on affective disorders.^{54–58} Aloia et al. reported in a small sample of older patients with OSA more subcortical WMH in the brain MRI of patients with a severe OSA as compared to those with minimal OSA, and a tendency for a positive correlation between these subcortical hyperintensities and depression scores on the Hamilton Depression Scale.⁵⁹

Neurobiology of depression and upper airway control in OSA: the role of serotonin

The high comorbidity of OSA and depression also suggests that both disorders may share a common neurobiological risk factor. On the neurotransmitter level, the serotonergic system has a central role as a neurobiological substrate underlying impairments in the regulations of mood, sleep-wakefulness cycle, and upper airway muscle tone control during sleep. Depression is associated with a functional decrease of

serotonergic neurotransmission, and is mostly responsible for the alterations in sleep as outlined above.⁶⁰

The physiopathology of OSA involves numerous factors, among whose the abnormal pharyngeal collapsibility during sleep is one of the most compelling. Serotonin delivery to upper airway dilator motor neurons has been shown to be reduced in dependency of the vigilance state.⁶¹ This leads to reductions in dilator muscle activity specifically during sleep, which may contribute to sleep apnea. However, whereas the role of serotonin in mood disorders has been largely documented, its involvement in the pathophysiology of sleep apnea remains to be clarified. Interestingly, molecules increasing 5-HT neurotransmission such as the Serotonin reuptake inhibitors (SSRI) are widely prescribed antidepressant molecules that are suggested to similarly improve the apnea hypopnea index in OSA. Serotonergic drugs such as fluoxetine, protryptiline and paroxetine have already been tested for OSA, with limited success and numerous adverse effects.⁶¹ Several 5-HT receptor ligands and bi-functional molecules are under development, which may in the future be able to target both, the depressive syndrome and OSA.

Shared risk factors: OSA and depression share common risk factors, which may partly explain their high comorbidity in the general population. Very frequently in studies of the impact of OSA on cognitive and psychological functioning, a conglomerate of disorders is shown to contribute to the overall neuropsychological outcome. Therefore, the presence of a polyopathy often associated with OSA, such as obesity, cardiovascular disease, hypertension and diabetes, should increase the suspicion of an underlying or coexisting OSA in a depressed patient.

Both, depression and OSA, have independently been shown to be associated with metabolic syndrome, and also with the development of cardiovascular disease.^{62,63} The association between depression and metabolic syndrome has been suggested to be reciprocal,⁶⁴ and a priori not attributable to genetic factors as twin studies revealed.⁶⁵ In particular, insulin resistance (IR) has been suggested to contribute to the pathophysiology of depressive disorder and has been proposed to subserve the association between depression and cardiovascular disease.⁶⁶ Similarly, OSA has been observed to be independently associated with the cardiovascular risk factors comprising metabolic syndrome,⁶⁷ in particular IR.⁶⁸ The magnitude of this association has even led researchers to suggest that metabolic syndrome should encompass OSA.⁶⁹

Although OSA and depression share these common risk factors, there are currently no studies available which have investigated the issue of antecedent or consequence in the relationship between depression, OSA and metabolic syndrome, and if and how these three highly prevalent disorders may interact to exacerbate the risk for cardio – and cerebrovascular morbidity and mortality.

Clinical application: As a consequence of the complex relationship between depression and OSA, the assessment of a patient's individual sleep history should be included in the standard psychiatric clinical interview, and specifically in the assessment of a depressive syndrome. A clinician should suspect OSA particularly in those depressed patients who present with its cardinal symptoms, namely, 1) loud snoring or

intermittent pauses in respiration, as witnessed by a bed partner, associated with 2) excessive daytime sleepiness (EDS). Given that patients often deny the latter, standardized questionnaires such as the Epworth Sleepiness Scale (ESS)⁷⁰ or the Functional Outcome Sleep Questionnaire (FOSQ)⁷¹ are useful tools to assess EDS. The ESS asks the patients to rate their chances to fall asleep during periods of relaxation or inactivity (such as reading, watching television), but also in more active settings (driving a car, sitting and talking to someone). EDS is by far the most frequent daytime symptom of OSA, whereas nocturnal symptoms include restlessness, nocturia, excessive salivation and sweating, gastroesophageal reflux, as well as headache and dry mouth or throat in the morning on awakening. Furthermore, the clinical picture frequently includes obesity and hypertension, and, in those patients who are not obese, special facial abnormalities which narrow the upper airway, such as retrognathia or micrognathia.

However, it should be kept in mind that OSA may not be immediately apparent, but might present in an atypical fashion, with irritability, tiredness, disrupted sleep, difficulty concentrating, difficulties accomplishing tasks and generally decreased psychomotor performance.¹² Women are more likely to present with these symptoms,^{22,72,73} and have been suggested to be particularly underdiagnosed because of their atypical symptoms.⁷⁴ The importance of the sleep-wake complaints in a patient's depressive profile, and the onset of those complaints prior to the development of the depressive psychopathology should draw the clinician's attention to a potential underlying or coexisting OSA.⁷⁵

Third, particular attention should be paid to depressive patients who are resistant to treatment. In this case, OSA should be excluded as a major underlying contributing factor,⁷⁶ as treatment of OSA could improve not only the compliance to pharmacological antidepressant treatment, but also the treatment response rate for depression.⁷⁷ Fourth, comorbid disorders of OSA may also catch the attention of the treating psychiatrist. In addition to the outlined association with the metabolic syndrome, Farney et al. observed that the likelihood of OSA increased significantly when either antihypertensive or antidepressant medications had been prescribed.⁷⁸

Depressed patients with a suspected OSA should be referred to a sleep disorders center for evaluation by nocturnal polysomnography, to confirm the diagnosis of OSA or the presence of other forms of sleep disordered breathing, such as the upper airway resistance syndrome.⁷⁹ This is of particular importance, as some of the adjunct treatments to the current pharmacological treatment of depression may actually exacerbate the condition.

If the diagnosis of OSA has been established in a depressed patient, and treatment has been initiated, close follow-up of the improvement of the depressive symptoms might give some indications as to the extent to which the presence of OSA may have contributed to the depressive symptomatology. However, as Baran and Richert point out,⁴¹ the aforementioned diagnostic challenge of a depressive syndrome in the presence of OSA currently remains unresolved.

On the other hand, systematic assessment of depressive symptoms with standardized clinical questionnaires in OSA patients is generally part of the evaluation process in all major

sleep disorder centers. However, as these questionnaires have not been specifically designed to assess depression in OSA patients,⁸⁰ they might be inappropriate to assess depression in this population, given that it is still unclear if OSA and depression display a true comorbidity or only share similar symptoms.⁴¹ Typically, patients with severe depressive symptoms should be referred to a psychiatrist, particularly if such symptoms do not regress or if fatigue lingers after efficient treatment of OSA.⁸¹

Conclusion

Recent studies underscore the existence of a complex relationship between depression and OSA in terms of clinical presentation, underlying pathophysiology and treatment. It should incite the treating psychiatrist to be highly aware of a possibly underlying or coexisting OSA in depressed patients. Up to 20% of all patients presenting with a diagnosed depressive syndrome may also have OSA, and vice versa. This relationship might vary widely, depending on age, gender, AHI cut-off and general demographic and health characteristics of the population under investigation. Future clinical research in this area should specifically examine depressed patient populations, taking into account the different sub-type of mood disorders, and investigate a broader range of depressive symptomatology in OSA patients. Basic research should further investigate the causal relationship between depression and OSA, as well as the potential mechanisms by which both disorders may interact.

References

- 1 Gastaut H, Tassinari CA, Duron B: [Polygraphic study of diurnal and nocturnal (hypnic and respiratory) episodal manifestations of Pickwick syndrome]. *Rev Neurol (Paris)* 1965, 112:568-579.
- 2 Guilleminault C, Tilkian A, Dement WC: The sleep apnea syndromes. *Annu Rev Med* 1976, 27:465-484.
- 3 Sleep-related breathing disorders in adults: recommendations for syndrome definition and measurement techniques in clinical research. The Report of the American Academy of Sleep Medicine Task Force. *Sleep* 1999, 22:667-689.
- 4 Ali NJPDSJR: The prevalence of snoring, sleep disturbance and sleep related breathing disorders and their relation to daytime sleepiness in the 4-5 year old children. *Am Rev Respir Dis* 1991, 143:A381.
- 5 Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S: The occurrence of sleep-disordered breathing among middle-aged adults. *N Engl J Med* 1993, 328:1230-1235.
- 6 Krieger J, Mangin P, Kurtz D: [Respiratory changes during sleep in healthy elderly subjects (author's transl)]. *Rev Electroencephalogr Neurophysiol Clin* 1980, 10:177-185.
- 7 Carskadon MA, Dement WC: Respiration during sleep in the aged human. *J Gerontol* 1981, 36:420-423.
- 8 Ancoli-Israel S: Epidemiology of sleep disorders. *Clin Geriatr Med* 1989, 5:347-362.
- 9 Ancoli-Israel S, Kripke DF, Klauber MR, Mason WJ, Fell R, Kaplan O: Sleep-disordered breathing in community-dwelling elderly. *Sleep* 1991, 14:486-495.
- 10 Guilleminault C, Eldridge FL, Tilkian A, Simmons FB, Dement WC: Sleep apnea syndrome due to upper airway obstruction: a review of 25 cases. *Arch Intern Med* 1977, 137:296-300.
- 11 Reynolds CF, Kupfer DJ, McEachran AB, Taska LS, Sewitch DE, Coble PA: Depressive psychopathology in male sleep apneics. *J Clin Psychiatry* 1984, 45:287-290.

- 12 Millman RP, Fogel BS, McNamara ME, Carlisle CC: Depression as a manifestation of obstructive sleep apnea: reversal with nasal continuous positive airway pressure. *J Clin Psychiatry* 1989, 50:348-351.
- 13 Mosko S, Zetin M, Glen S, Garber D, DeAntonio M, Sassin J, McAnich J, Warren S: Self-reported depressive symptomatology, mood ratings, and treatment outcome in sleep disorders patients. *J Clin Psychol* 1989, 45:51-60.
- 14 Beutler LE, Ware JC, Karacan I, Thornby JI: Differentiating psychological characteristics of patients with sleep apnea and narcolepsy. *Sleep* 1981, 4:39-47.
- 15 Kales A, Caldwell AB, Cadieux RJ, Vela-Bueno A, Ruch LG, Mayes SD: Severe obstructive sleep apnea—II: Associated psychopathology and psychosocial consequences. *J Chronic Dis* 1985, 38:427-434.
- 16 Ramos Platon MJ, Espinar Sierra J: Changes in psychopathological symptoms in sleep apnea patients after treatment with nasal continuous positive airway pressure. *Int J Neurosci* 1992, 62:173-195.
- 17 Aikens JE, Caruana-Montaldo B, Vanable PA, Tadimeti L, Mendelson WB: MMPI correlates of sleep and respiratory disturbance in obstructive sleep apnea. *Sleep* 1999, 22:362-369.
- 18 Aikens JE, Mendelson WB: A matched comparison of MMPI responses in patients with primary snoring or obstructive sleep apnea. *Sleep* 1999, 22:355-359.
- 19 Aikens JE, Vanable PA, Tadimeti L, Caruana-Montaldo B, Mendelson WB: Differential rates of psychopathology symptoms in periodic limb movement disorder, obstructive sleep apnea, psychophysiological insomnia, and insomnia with psychiatric disorder. *Sleep* 1999, 22:775-780.
- 20 Ohayon MM: The effects of breathing-related sleep disorders on mood disturbances in the general population. *J Clin Psychiatry* 2003, 64:1195-200; quiz, 1274-6.
- 21 Phillips BA, Berry DT, Lipke-Molby TC: Sleep-disordered breathing in healthy, aged persons. Fifth and final year follow-up. *Chest* 1996, 110:654-658.
- 22 Pillar G, Lavie P: Psychiatric symptoms in sleep apnea syndrome: effects of gender and respiratory disturbance index. *Chest* 1998, 114:697-703.
- 23 Bardwell WA, Berry CC, Ancoli-Israel S, Dimsdale JE: Psychological correlates of sleep apnea. *J Psychosom Res* 1999, 47:583-596.
- 24 White J, Cates C, Wright J: Continuous positive airways pressure for obstructive sleep apnoea. *Cochrane Database Syst Rev* 2002:CD001106.
- 25 Powell NB, Riley RW, Robinson A: Surgical management of obstructive sleep apnea syndrome. *Clin Chest Med* 1998, 19:77-86.
- 26 Derderian SS, Bridenbaugh RH, Rajagopal KR: Neuropsychologic symptoms in obstructive sleep apnea improve after treatment with nasal continuous positive airway pressure. *Chest* 1988, 94:1023-1027.
- 27 Engleman HM, Martin SE, Deary IJ, Douglas NJ: Effect of continuous positive airway pressure treatment on daytime function in sleep apnoea/hypopnoea syndrome. *Lancet* 1994, 343:572-575.
- 28 Engleman HM, Martin SE, Deary IJ, Douglas NJ: Effect of CPAP therapy on daytime function in patients with mild sleep apnoea/hypopnoea syndrome. *Thorax* 1997, 52:114-119.
- 29 Means MK, Lichstein KL, Edinger JD, Taylor DJ, Durrence HH, Husain AM, Aguillard RN, Radtke RA: Changes in depressive symptoms after continuous positive airway pressure treatment for obstructive sleep apnea. *Sleep Breath* 2003, 7:31-42.
- 30 Sanchez AI, Buena-Casal G, Bermudez MP, Casas-Maldonado F: The effects of continuous positive air pressure treatment on anxiety and depression levels in apnea patients. *Psychiatry Clin Neurosci* 2001, 55:641-646.
- 31 McMahon JP, Foresman BH, Chisholm RC: The influence of CPAP on the neurobehavioral performance of patients with obstructive sleep apnea hypopnea syndrome: a systematic review. *Wmj* 2003, 102:36-43.
- 32 Borak J, Cieslicki JK, Koziej M, Matuszewski A, Zielinski J: Effects of CPAP treatment on psychological status in patients with severe obstructive sleep apnoea. *J Sleep Res* 1996, 5:123-127.
- 33 Munoz A, Mayoralas LR, Barbe F, Pericas J, Agusti AG: Long-term effects of CPAP on daytime functioning in patients with sleep apnoea syndrome. *Eur Respir J* 2000, 15:676-681.
- 34 Yu BH, Ancoli-Israel S, Dimsdale JE: Effect of CPAP treatment on mood states in patients with sleep apnea. *J Psychiatr Res* 1999, 33:427-432.
- 35 Henke KG, Grady JJ, Kuna ST: Effect of nasal continuous positive airway pressure on neuropsychological function in sleep apnea-hypopnea syndrome. A randomized, placebo-controlled trial. *Am J Respir Crit Care Med* 2001, 163:911-917.
- 36 Edinger JD, Carwile S, Miller P, Hope V, Mayti C: Psychological status, syndromic measures, and compliance with nasal CPAP therapy for sleep apnea. *Percept Mot Skills* 1994, 78:1116-1118.
- 37 Lewis KE, Seale L, Bartle IE, Watkins AJ, Ebdon P: Early predictors of CPAP use for the treatment of obstructive sleep apnea. *Sleep* 2004, 27:134-138.
- 38 Reynolds CF, Kupfer DJ, Taska LS, Hoch CC, Sewitch DE, Restifo K, Spiker DG, Zimmer B, Marin RS, Nelson J, et al.: Sleep apnea in Alzheimer's dementia: correlation with mental deterioration. *J Clin Psychiatry* 1985, 46:257-261.
- 39 Miles LE, Dement WC: Sleep and aging. *Sleep* 1980, 3:1-220.
- 40 Guilleminault C: Benzodiazepines, breathing, and sleep. *Am J Med* 1990, 88:25S-28S.
- 41 Baran AS, Richert AC: Obstructive sleep apnea and depression. *CNS Spectr* 2003, 8:128-134.
- 42 Diagnostic and statistical manual of mental disorders. 4th edition. Washington, DC, American Psychiatric Association; 1994.
- 43 Benca RM, Obermeyer WH, Thisted RA, Gillin JC: Sleep and psychiatric disorders. A meta-analysis. *Arch Gen Psychiatry* 1992, 49:651-68; discussion 669-70.
- 44 Smith PL, Gold AR, Meyers DA, Haponik EF, Blecker ER: Weight loss in mildly to moderately obese patients with obstructive sleep apnea. *Ann Intern Med* 1985, 103:850-855.
- 45 Weitzman ED, Kahn E, Pollak CP: Quantitative analysis of sleep and sleep apnea before and after tracheostomy in patients with the hypersomnia-sleep apnea syndrome. *Sleep* 1980, 3:407-423.
- 46 Bardwell WA, Moore P, Ancoli-Israel S, Dimsdale JE: Does obstructive sleep apnea confound sleep architecture findings in subjects with depressive symptoms? *Biol Psychiatry* 2000, 48:1001-1009.
- 47 Cohen-Zion M, Stepnowsky C, Marler, Shochat T, Kripke DF, Ancoli-Israel S: Changes in cognitive function associated with sleep disordered breathing in older people. *J Am Geriatr Soc* 2001, 49:1622-1627.
- 48 Sforza E, de Saint Hilaire Z, Pelissolo A, RoCHAT T, Ibanez V: Personality, anxiety and mood traits in patients with sleep-related breathing disorders: effect of reduced daytime

- alertness. *Sleep Med* 2002, 3:139-145.
- 49 Yue W, Hao W, Liu P, Liu T, Ni M, Guo Q: A case-control study on psychological symptoms in sleep apnea-hypopnea syndrome. *Can J Psychiatry* 2003, 48:318-323.
 - 50 Engleman HM, Kingshott RN, Martin SE, Douglas NJ: Cognitive function in the sleep apnea/hypopnea syndrome (SAHS). *Sleep* 2000, 23 Suppl 4:S102-8.
 - 51 Kamba M, Suto Y, Ohta Y, Inoue Y, Matsuda E: Cerebral metabolism in sleep apnea. Evaluation by magnetic resonance spectroscopy. *Am J Respir Crit Care Med* 1997, 156:296-298.
 - 52 Kamba M, Inoue Y, Higami S, Suto Y, Ogawa T, Chen W: Cerebral metabolic impairment in patients with obstructive sleep apnoea: an independent association of obstructive sleep apnoea with white matter change. *J Neurol Neurosurg Psychiatry* 2001, 71:334-339.
 - 53 McGown AD, Makker H, Elwell C, Al Rawi PG, Valipour A, Spiro SG: Measurement of changes in cytochrome oxidase redox state during obstructive sleep apnea using near-infrared spectroscopy. *Sleep* 2003, 26:710-716.
 - 54 Taylor WD, MacFall JR, Steffens DC, Payne ME, Provenzale JM, Krishnan KR: Localization of age associated white matter hyperintensities in late-life depression. *Prog Neuropsychopharmacol Biol Psychiatry* 2003, 27:539-544.
 - 55 Silverstone T, McPherson H, Li Q, Doyle T: Deep white matter hyperintensities in patients with bipolar depression, unipolar depression and age-matched control subjects. *Bipolar Disord* 2003, 5:53-57.
 - 56 Sassi RB, Brambilla P, Nicoletti M, Mallinger AG, Frank E, Kupfer DJ, Keshavan MS, Soares JC: White matter hyperintensities in bipolar and unipolar patients with relatively mild-to-moderate illness severity. *J Affect Disord* 2003, 77:237-245.
 - 57 Thomas AJ, O'Brien JT, Barber R, McMeekin W, Perry R: A neuropathological study of periventricular white matter hyperintensities in major depression. *J Affect Disord* 2003, 76:49-54.
 - 58 Firbank MJ, Lloyd AJ, Ferrier N, O'Brien JT: A volumetric study of MRI signal hyperintensities in late-life depression. *Am J Geriatr Psychiatry* 2004, 12:606-612.
 - 59 Aloia MS, Arnedt JT, Davis JD, Riggs RL, Byrd D: Neuropsychological sequelae of obstructive sleep apnea-hypopnea syndrome: a critical review. *J Int Neuropsychol Soc* 2004, 10:772-785.
 - 60 Adrien J: Neurobiological bases for the relation between sleep and depression. *Sleep Med Rev* 2002, 6:341-351.
 - 61 Veasey SC: Serotonin agonists and antagonists in obstructive sleep apnea: therapeutic potential. *Am J Respir Med* 2003, 2:21-29.
 - 62 Gami AS, Somers VK: Obstructive sleep apnoea, metabolic syndrome, and cardiovascular outcomes. *Eur Heart J* 2004, 25:709-711.
 - 63 Lett HS, Blumenthal JA, Babyak MA, Sherwood A, Strauman T, Robins C, Newman MF: Depression as a risk factor for coronary artery disease: evidence, mechanisms, and treatment. *Psychosom Med* 2004, 66:305-315.
 - 64 Raikkonen K, Matthews KA, Kuller LH: The relationship between psychological risk attributes and the metabolic syndrome in healthy women: antecedent or consequence? *Metabolism* 2002, 51:1573-1577.
 - 65 McCaffery JM, Niaura R, Todaro JF, Swan GE, Carmelli D: Depressive symptoms and metabolic risk in adult male twins enrolled in the National Heart, Lung, and Blood Institute twin study. *Psychosom Med* 2003, 65:490-497.
 - 66 Ramasubbu R: Insulin resistance: a metabolic link between depressive disorder and atherosclerotic vascular diseases. *Med Hypotheses* 2002, 59:537-551.
 - 67 Coughlin SR, Mawdsley L, Mugarza JA, Calverley PM, Wilding JP: Obstructive sleep apnoea is independently associated with an increased prevalence of metabolic syndrome. *Eur Heart J* 2004, 25:735-741.
 - 68 Ip MS, Lam B, Ng MM, Lam WK, Tsang KW, Lam KS: Obstructive sleep apnea is independently associated with insulin resistance. *Am J Respir Crit Care Med* 2002, 165:670-676.
 - 69 Wilcox I, McNamara SG, Collins FL, Grunstein RR, Sullivan CE: "Syndrome Z": the interaction of sleep apnoea, vascular risk factors and heart disease. *Thorax* 1998, 53 Suppl 3:S25-8.
 - 70 Johns MW: A new method for measuring daytime sleepiness: the Epworth sleepiness scale. *Sleep* 1991, 14:540-545.
 - 71 Weaver TE, Laizner AM, Evans LK, Maislin G, Chugh DK, Lyon K, Smith PL, Schwartz AR, Redline S, Pack AI, Dinges DF: An instrument to measure functional status outcomes for disorders of excessive sleepiness. *Sleep* 1997, 20:835-843.
 - 72 Collop NA, Adkins D, Phillips BA: Gender differences in sleep and sleep-disordered breathing. *Clin Chest Med* 2004, 25:257-268.
 - 73 Quintana-Gallego E, Carmona-Bernal C, Capote F, Sanchez-Armengol A, Botbol-Benhamou G, Polo-Padillo J, Castillo-Gomez J: Gender differences in obstructive sleep apnea syndrome: a clinical study of 1166 patients. *Respir Med* 2004, 98:984-989.
 - 74 Young T, Hutton R, Finn L, Badr S, Palta M: The gender bias in sleep apnea diagnosis. Are women missed because they have different symptoms? *Arch Intern Med* 1996, 156:2445-2451.
 - 75 Reynolds CF, Coble PA, Spiker DG, Neil JF, Holzer BC, Kupfer DJ: Prevalence of sleep apnea and nocturnal myoclonus in major affective disorders: clinical and polysomnographic findings. *J Nerv Ment Dis* 1982, 170:565-567.
 - 76 Kaplan R: Obstructive sleep apnoea and depression—diagnostic and treatment implications. *Aust N Z J Psychiatry* 1992, 26:586-591.
 - 77 Fleming JA, Fleetham JA, Taylor DR, Remick RA: A case report of obstructive sleep apnea in a patient with bipolar affective disorder. *Can J Psychiatry* 1985, 30:437-439.
 - 78 Farney RJ, Lugo A, Jensen RL, Walker JM, Cloward TV: Simultaneous use of antidepressant and antihypertensive medications increases likelihood of diagnosis of obstructive sleep apnea syndrome. *Chest* 2004, 125:1279-1285.
 - 79 Guilleminault C, Stoohs R, Clerk A, Cetel M, Maistros P: A cause of excessive daytime sleepiness. The upper airway resistance syndrome. *Chest* 1993, 104:781-787.
 - 80 Andrews JG, Oei TP: The roles of depression and anxiety in the understanding and treatment of Obstructive Sleep Apnea Syndrome. *Clin Psychol Rev* 2004, 24:1031-1049.
 - 81 Bardwell WA, Moore P, Ancoli-Israel S, Dimsdale JE: Fatigue in obstructive sleep apnea: driven by depressive symptoms instead of apnea severity? *Am J Psychiatry* 2003, 160:350-355.

Upper Airway Dynamics During Negative Expiratory Pressure in Apneic and Non-Apneic Awake Snorers

A. Ferretti, P. Giampiccolo, S. Redolfi, S. Mondini, F. Cirignotta, A. Cavalli, C. Tantucci

Abstract

Background: The ability of negative expiratory pressure (NEP) technique to differentiate between awake snorers with and without obstructive sleep apnea-hypopnea (OSAH) was investigated.

Methods: Forty-eight subjects with sleep disordered breathing (SDB) and 7 healthy subjects, as non-snorer controls, underwent the NEP application of -5 and -7 cmH₂O in the seated and supine position during wakefulness, after performing a sleep study. The upper airway collapsibility was assessed by computing the volume exhaled during the first 0.5 sec. ($V_{NEP_{0.5}}$) and 1 sec. (V_{NEP_1}) following the NEP start.

Results: Patients with severe ($AHI \geq 30$) ($n = 19$) and mild-to-moderate ($AHI < 30$ and > 5) ($n = 15$) OSAH had lower $V_{NEP_{0.5}}$ (340 ± 88 ml) as compared to snorers ($AHI \leq 5$) ($n = 14$) (427 ± 101 ml; $p < 0.01$) and controls ($n = 7$) (492 ± 69 ml; $p < 0.001$) in the supine position with NEP -5 cmH₂O. Less significant differences among the different groups were observed for $V_{NEP_{0.5}}$ in the seated position with NEP -5 cmH₂O and in both positions with NEP -7 cmH₂O (only OSAH patients vs controls, $p < 0.001$). Similar results were obtained for V_{NEP_1} in either position by using both NEP -5 cmH₂O and -7 cmH₂O. In spite of this, a substantial overlapping of $V_{NEP_{0.5}}$ and V_{NEP_1} between snorers and OSAH patients did not allow to identify a reliable diagnostic cut-off level. An inverse correlation with AHI was found for $V_{NEP_{0.5}}$ in the supine position with NEP -5 cmH₂O ($r_s = -0.46$, $p < 0.05$) in severe OSAH patients.

Conclusion: The awake OSAH patients exhibit values of $V_{NEP_{0.5}}$ and V_{NEP_1} lesser than those of awake snorers. The NEP technique, however, appears to have a limited usefulness as clinical tool for routine screening of the OSAH patients during wakefulness.

Introduction

Among the mechanical factors that are believed to promote obstructive sleep apnea/hypopnea (OSAH), the increase in passive upper airway compliance, as assessed by the pharyngeal volume (area)-pressure relationship in the absence of upper airway dilator muscle activity, has been repeatedly emphasized.¹⁻⁶ This feature influences for a given transmural pressure the end-expiratory cross-sectional area at different levels of the upper airways and may be crucial for the development of upper airway narrowing and/or closure at the onset of inspiration during sleep, when the neural activation of upper airway dilator muscles decreases.^{7,8} Moreover, the patients suffering from OSAH exhibited less negative (sometimes positive) closing (or critical) pressure of the passive upper airways (i.e. the pressure inside the upper airways when they close), as compared to sex, age and body mass index matched snorers and normal subjects.^{3,9-11} The increased critical pressure that is considered to reflect a high extraluminal pressure has been ascribed in apneic patients to structural abnormalities such as parapharyngeal fat deposits in obesity and/or reduced cross-section of bony structures of the lower face in cranio-facial anomalies.^{12,13} In fact, several observations suggest that either obesity or cranio-facial anomalies would act to increase the tissue pressure surrounding the pharyngeal airway, thus favoring OSAH by reducing the transmural pharyngeal pressure and making the upper airways easier to narrow for a given compliance. In addition, there is compelling evidence that the upper airways have a smaller lumen during wakefulness^{8,13,14} and sleep³ in OSAH patients, who show an increase in the upper airway resistance,¹⁵⁻¹⁸ often assuming an anterior-posterior configuration of their major axis with a prevalent lateral narrowing.^{8,19} These factors tend to increase both the pharyngeal compliance, which is volume and shape dependent, and the closing pressure. Recently, pharyngeal airway length has

Authors Ferretti and Cavalli are with the Division of Pneumology, S. Orsola-Malpighi Hospital, Bologna, Italy; Giampiccolo is with the Pneumology Unit, ASL, Imola, Italy; Redolfi and Tantucci are with the Respiratory Medicine Unit, Department of Internal Medicine, University of Brescia, Italy; Mondini and Cirignotta are with the Neurology Unit, S. Orsola-Malpighi Hospital, University of Bologna, Italy. Reprinted from BioMed Central Ltd, Respiratory Research, © 2006 Ferretti et al; licensee BioMed Central Ltd. This is an Open Access article distributed under the terms of the Creative Commons Attribution License.

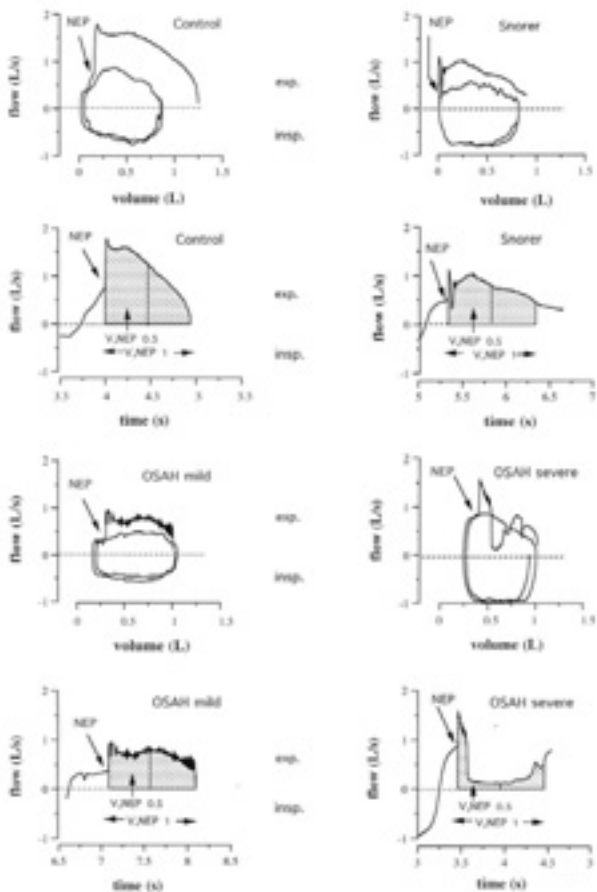


Figure 1
Supine tidal flow-volume curves (control and during NEP of $-5\text{ cmH}_2\text{O}$) and corresponding expiratory flow-time curves (only during NEP) in representative subjects of the different groups. The hatched areas under the flow measure the volume exhaled in the first 0.5 sec. ($V_{\text{NEP}_{0.5}}$) and 1 sec. (V_{NEP_1}) after NEP application.

been found to be greater in OSAH patients, possibly influencing its collapsibility.^{20,21}

Hence, several, concurrent, inter-related mechanisms (increased compliance, decreased transmural pressure, smaller size and greater length of the upper airways) might enhance the pharyngeal collapsibility in patients with OSAH.

Therefore, simple assessment of upper airway mechanics during wakefulness could identify OSAH subjects and select them for standard polysomnography. In normal awake subjects the application of small negative expiratory pressure (NEP) transients at the onset of resting expiration does not elicit reflex activity of the genioglossus nor changes in upper airway resistance per se.^{22,23} Under these conditions, the flow dynamics at the beginning of the expiratory phase during NEP application are expected to reflect the mechanical behavior of the pharyngeal airway in a “quasi-passive” condition even during wakefulness. Accordingly, the aim of our study was i) to investigate if volume exhaled during early application of NEP at the onset of quiet expiration at rest was different in OSAH patients, snorers and normal subjects, suggesting different degrees of pharyngeal collapsibility among these groups and ii) if these differences could be used to distinguish non-apneic from apneic snorers.

Methods

Subjects: In a prospective, randomized study we investigated at the Division of Pneumology of the S. Orsola-Malpighi Hospital of Bologna the early expiratory flow dynamics after the application of a small (-5 to $-7\text{ cmH}_2\text{O}$) negative pressure at the mouth in 48 awake male subjects coming from the Neurology Unit who had performed a polysomnographic study in the Sleep Center because of suspected sleep disordered breathing. We excluded those with obvious anatomical defects such as cranio-facial and/or severe otorino-laryngoiatric (ORL) abnormalities, or with neurological and endocrine diseases known to be causally associated with SDB. Subjects affected by cardiac and respiratory disorders capable of causing intra-thoracic tidal expiratory flow limitation (EFL) were also excluded, as well as obese subjects with tidal intra-thoracic EFL in either position. Subjects were not treated with drugs active on CNS or suffered from chronic alcoholism. Among the enrolled subjects 34 resulted affected by obstructive sleep apnea-hypopnea (OSAH) and 14 were snorers without OSAH (Sn). Seven male subjects, non-apneic, non-snorer, as assessed by nocturnal polysomnography, were recruited from the Hospital staff as controls. The study was approved by the local Ethics Committee and an informed consent was obtained from each subject.

Study design – Sleep study: All subjects were examined at the Sleep Center performing an overnight polysomnographic study by recording the following parameters: nasal pressure (by nasal cannula), oral flow (by thermistor), abdominal and rib cage movements (by piezo-sensors), oxygen saturation and heart rate (by finger oxymeter), snoring (by microphone), body movements and body posture. Respiratory events were defined as obstructive apnea in the presence of nose and mouth airflow cessation for at least 10 sec with concomitant inspiratory efforts and as obstructive hypopnea in the presence of discernable inspiratory airflow reduction with inspiratory efforts accompanied by a decrease of $>3\%$ in oxygen saturation. The results were expressed as the number of apnea and hypopnea per hour of sleep (apnea-hypopnea index, AHI).²⁴ The subjects were categorized according to AHI as non-apneic snorers (AHI ≤ 5) and snorers with mild-to-moderate (AHI <30 and >5) or severe (AHI ≥ 30) OSAH.

NEP testing: Subsequently, the subjects were sent to the Division of Pneumology to evaluate the upper airway mechanics looking at the flow-time relationship in the early tidal expiration during strict wakefulness. Expiratory flow dynamics was assessed during the application of a negative expiratory pressure at the mouth (NEP technique). NEP was applied randomly at two different levels, i.e. $-5\text{ cmH}_2\text{O}$ and $-7\text{ cmH}_2\text{O}$, initially in the seated position and later, 10 minutes after assuming the supine posture. In both positions and at both levels of negative pressure, at least 5 NEP breath-tests were performed at intervals of 5–10 respiratory cycles, always when the patient had resumed regular breathing according to the spirogram that was continuously displayed on the computer monitor. In this respect, great care was placed to check the level of the end-expiratory lung volume. The expiratory flow recorded under each NEP application was measured in the first 0.5 and 1 sec from the onset of NEP administration to compute by time integration the volume exhaled in these time intervals, labeled hence for $V_{\text{NEP}_{0.5}}$ and V_{NEP_1} , respectively (Fig. 1). For all subjects in each experimental condition (different posture and negative pressure levels) the mean value of $V_{\text{NEP}_{0.5}}$ and

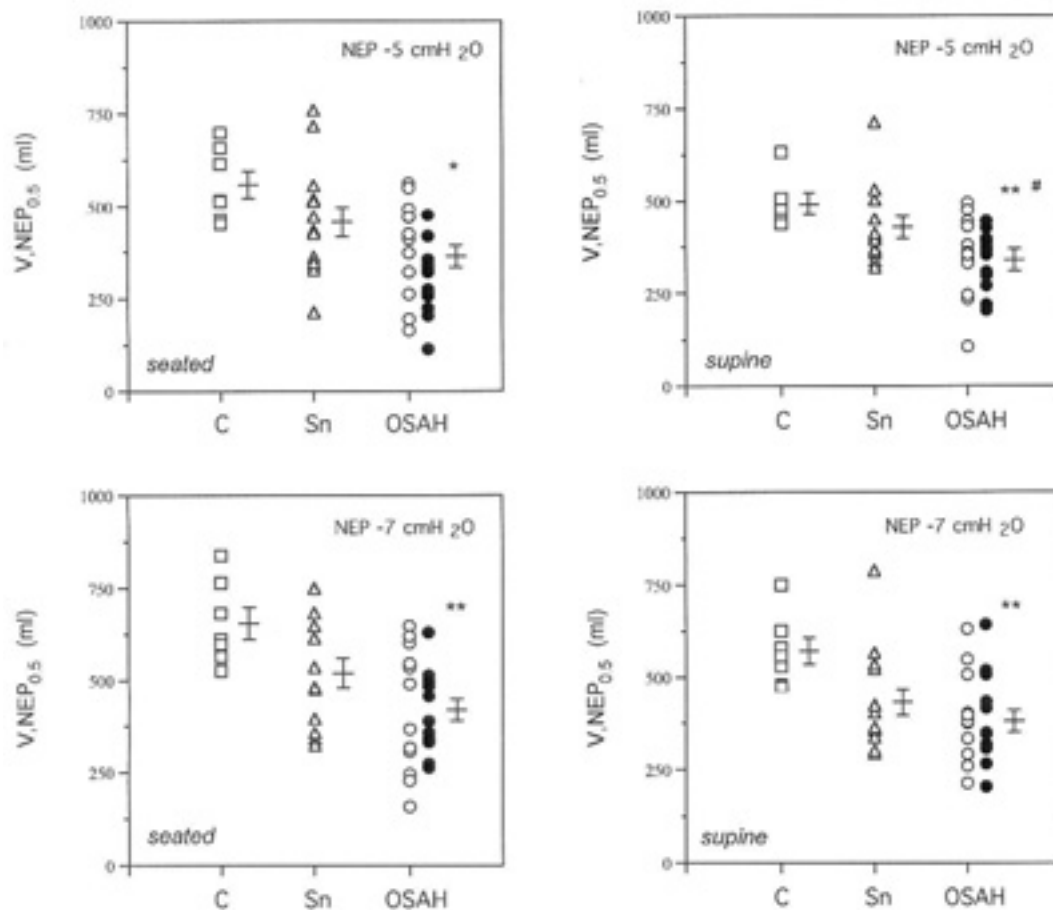


Figure 2
 Individual values of $V_{1,NEP_{0.5}}$ in seated and supine position at two NEP levels in patients with obstructive sleep apnea-hypopnea (OSAH) (circles, white for mild-to-moderate OSAH and black for severe OSAH), snorers (Sn) (triangles) and controls (C) (squares).
 * $p < 0.01$ vs C; ** $p < 0.001$ vs C; # $p < 0.05$ vs Sn.

V_{1,NEP_1} was calculated, after discarding the highest and the lowest value, by averaging those obtained during at least 3 acceptable NEP maneuvers. It should be noted that the NEP was applied unknown to the subject by a computer at the very onset of the tidal expiration. We also computed the differences between $V_{1,NEP_{0.5}}$ and V_{1,NEP_1} and the corresponding volumes exhaled during preceding spontaneous expirations ($\Delta V_{1,NEP_{0.5}}$ and $\Delta V_{1,NEP_1}$) in the different groups of subjects. These measurements were performed in both positions and at the same different levels of NEP applied, aiming to normalize in each subject the $V_{1,NEP_{0.5}}$ and V_{1,NEP_1} values for the baseline expiratory flows and volumes. The physician who performed

and assessed the NEP tests was blinded to the polysomnographic results.

Pulmonary function testing: All subjects underwent spirometric measurements using a computerized system (V_{max} 22; Sensor Medics, Yorba Linda, CA) in seated position. Slow vital capacity (VC) and three acceptable and reproducible maximal full flow/volume curves were obtained. Subjects inspired to TLC and then expired forcefully without an end-inspiratory pause to obtain forced vital capacity. The predicted values for volumes and flows were those proposed by the European Community for Coal and Steel.²⁵

Table 1: Anthropometric and functional characteristics of subjects.

	Controls	Snorers	OSAH, mild	OSAH, severe
Subjects (n)	7	14	15	19
Age (yrs)	40 ± 8	49 ± 13	49 ± 10	53 ± 8 *
BMI (kg/m ²)	24 ± 3	27 ± 4	26 ± 3	29 ± 3 *
FEV1 (% pred)	98 ± 10	96 ± 31	103 ± 25	95 ± 26
FVC (% pred)	97 ± 15	96 ± 24	100 ± 24	93 ± 20
FEV1/FVC (%)	88 ± 12	79 ± 11	81 ± 11	86 ± 1
AHI	2 ± 0.4	4 ± 2	18 ± 10	59 ± 16

BMI = body mass index; FEV1 = forced expired volume in the first second; FVC = forced vital capacity; OSAH = obstructive sleep apnea-hypopnea; AHI = apnea-hypopnea index; data are mean ± SD; * $p < 0.01$ vs Controls.

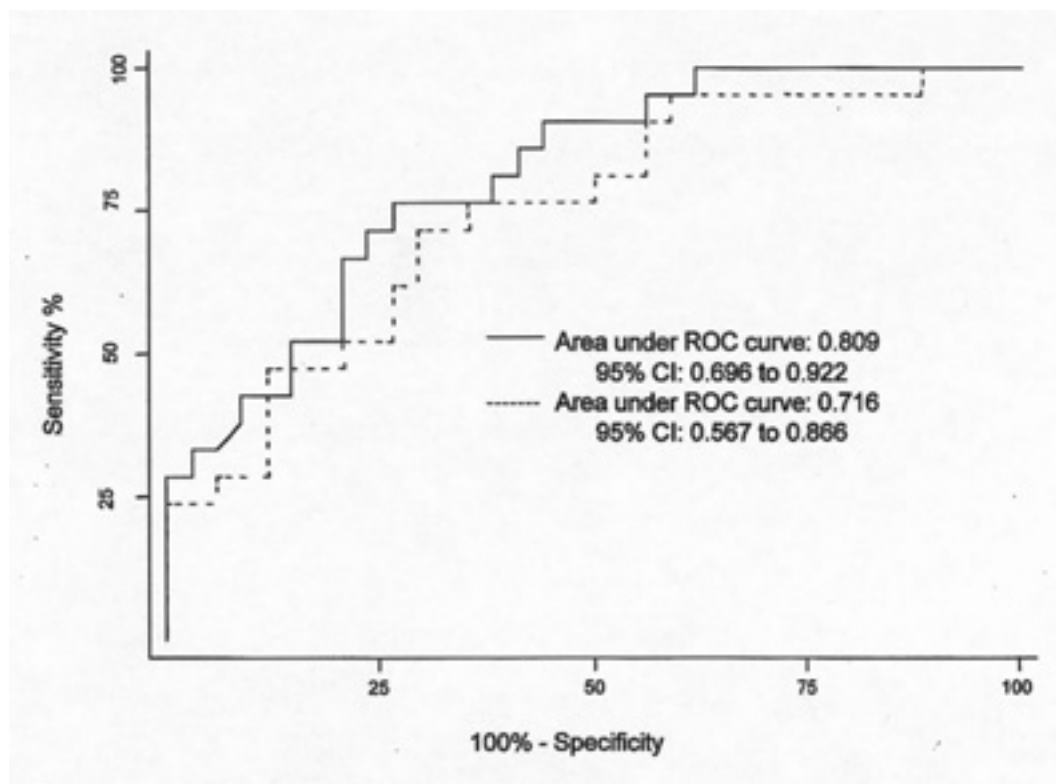


Figure 3
The receiver-operating characteristics (ROC) curves are shown for $V,NEP_{0.5}$ values during NEP (-5 cmH₂O) both in supine (continuous line) and seated (dashed line) position in 34 patients with OSAH and 21 subjects without OSAH. The area under the ROC curves reflects the ability of $V,NEP_{0.5}$ to distinguish subjects without and with OSAH (AHI>5).

Experimental NEP set-up: In both seated and supine position, all subjects wearing nose-clips breathed spontaneously room air through a flanged mouthpiece and a heated pneumotachograph (3700 series; Hans Rudolph, Kansas City, MO) connected to a differential pressure transducer (Raytech DP55 ± 3 cmH₂O; Raytech Instruments, Vancouver, BC, Canada) to measure the flow. The pneumotachograph was linear over the experimental flow range. Volume (V) was obtained by electrical time integration of the flow signal. Pressure was recorded at the mouth (P_m) via a rigid polyethylene catheter (internal diameter = 1.7 mm) connected to a differential pressure transducer

(Raytech DP55 ± 100 cmH₂O; Raytech Instruments). The pneumotachograph was assembled in series to a Venturi device that created a negative pressure in the circuit, whose magnitude could be precisely fixed. The application of the negative pressure did not affect the accuracy of the pneumotachograph which measured a flow less than 1 ml/s when the system was switched on. The Venturi device was connected to a solenoid valve (Asco electrical valve, model 8262G208; Ascoelectric, Ontario, Canada) controlled by a computer and automatically activated when the expiratory flow reached a pre-set threshold value (i.e.: 50 ml/s) and after a pre-set time delay (i.e.: 200 ms.).²⁶ In all instances the NEP application was timed to last until the lung volume corresponding to the end-expiratory lung volume of the previous control breath was reached or for at least 1.3 sec. The flow and pressure signals were amplified (AC bridge Amplifier-ABC module; Raytech Instruments), filtered through a low-pass filter at 50 Hz, sent to an A/D converter (Direc Physiologic Recording System; Raytech Instruments) connected to an IBM personal computer and sampled at 200 Hz. Both digitized signals were displayed in real time on the computer screen together with the volume signal. The tracings were continuously monitored both with respect to time and as flow/volume curves. All signals were calibrated independently and simultaneously recorded on the hard disk of the computer and were used for subsequent analysis. Data analysis was performed using data analysis software (Direc NEP, version 3.1; Raytech Instruments or Anadat, version 5.2; RHT-InfoDat; Montreal, Quebec, Canada).

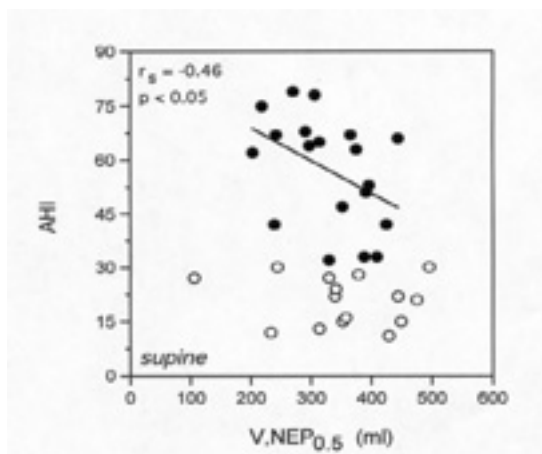


Figure 4
Relationship between AHI and $V,NEP_{0.5}$ in the supine position during NEP (-5 cmH₂O) in OSAH patients (white circles = mild-to-moderate OSAH; black circles = severe OSAH). The regression line refers only to severe OSAH patients.

Statistical analysis: Data are presented as mean ± standard deviation (SD). To assess and verify the normal distribution of the data in each group the Kolmogorov-Smirnov test was

Table 2: Values of $V_{NEP_{0.5}}$ and V_{NEP_1} at two different NEP levels in seated and supine position.

NEP	SEATED		SUPINE	
	-5 cmH ₂ O	-7 cmH ₂ O	-5 cmH ₂ O	-7 cmH ₂ O
$V_{NEP_{0.5}}$				
Controls	559 ± 98	655 ± 113	492 ± 69	571 ± 96
Snorers	457 ± 150	520 ± 147	427 ± 101	430 ± 134
OSAH	363 ± 123*	419 ± 132**	340 ± 88** #	379 ± 113**
OSAH, m	402 ± 129	428 ± 157	353 ± 103	387 ± 108
OSAH, s	332 ± 112	410 ± 112	329 ± 73	372 ± 119
V_{NEP_1}				
Controls	1036 ± 134	1128 ± 158	832 ± 95	920 ± 136
Snorers	864 ± 246	930 ± 274	737 ± 194	755 ± 224
OSAH	708 ± 189*	781 ± 210*	628 ± 136*	669 ± 177*
OSAH, m	732 ± 202	766 ± 230	625 ± 159	666 ± 178
OSAH, s	688 ± 182	792 ± 199	629 ± 120	671 ± 180

OSAH = obstructive sleep apnea-hypopnea; m = mild; s = severe; data are mean ± SD; * $p < 0.01$ vs Controls; ** $p < 0.001$ vs Controls; # $p < 0.01$ vs Snorers

performed. Then, one-way ANOVA was used to compare data among groups both in seated and supine position and at different negative pressure and finally multiple comparisons, corrected by the Bonferroni method, were performed between groups, if allowed by the F-value. To assess differences in $V_{NEP_{0.5}}$ and V_{NEP_1} within groups between seated and supine posture and different levels of negative pressure a paired Student's test was applied. Correlations between quantitative variables were performed using the Spearman's rank-order test. A p value less than 0.05 was considered statistically significant. The receiver-operating characteristic curves (ROC) were performed to assess sensitivity and specificity of $V_{NEP_{0.5}}$ and V_{NEP_1} obtained with different levels of NEP in both positions to get optimal cut-offs.

Results: The anthropometric and functional characteristics of the subjects are shown in Table 1. Snorers and OSAH patients were well matched, but patients with severe OSAH were older and had greater BMI than controls ($p < 0.01$). No correlation, however, was present between $V_{NEP_{0.5}}$ and V_{NEP_1} and BMI in snorers and OSAH patients. None of the subjects had significant restrictive or obstructive ventilatory defect and exhibited tidal intrathoracic EFL in either position during NEP application.

The values (mean ± SD) of $V_{NEP_{0.5}}$ and V_{NEP_1} , in both positions and NEP levels, are shown in Table 2. The individual $V_{NEP_{0.5}}$ data in each group are shown in Fig. 2. Similar values of $V_{NEP_{0.5}}$ and V_{NEP_1} were obtained in subjects with mild-to-moderate and with severe OSAH in all experimental conditions and were treated as a single group for comparative analysis.

$\Delta V_{NEP_{0.5}}$ and ΔV_{NEP_1} reflected exactly what was shown by $V_{NEP_{0.5}}$ and V_{NEP_1} with no additional advantage in order to distinguish the different groups. Therefore, we did not consider these time-consuming indices for subsequent analysis.

Within each group $V_{NEP_{0.5}}$ and V_{NEP_1} were significantly higher with NEP -7 cmH₂O than with NEP -5 cmH₂O in both positions, and with the same negative pressure higher in the seated

position than in the supine one ($p < 0.05$ for controls, $p < 0.01$ for snorers and patients with OSAH).

The patients with OSAH consistently exhibited values of $V_{NEP_{0.5}}$ and V_{NEP_1} much lower than control subjects ($p < 0.001$), but had values of $V_{NEP_{0.5}}$ significantly reduced as compared to snorers only with NEP -5 cmH₂O in the supine position ($p < 0.01$) (Fig. 2).

The receiver operating characteristic (ROC) curves performed for $V_{NEP_{0.5}}$ and V_{NEP_1} in both positions at the two different levels of NEP showed similar areas with the highest value for $V_{NEP_{0.5}}$ in the supine position using NEP of -5 cmH₂O (Fig. 3). Under these conditions, the optimal cut-off $V_{NEP_{0.5}}$ value of 393 ml had a sensitivity of 76% and a specificity of 74% to detect the presence of OSAH with a likelihood ratio for positive results of 2.9. Accordingly, its positive and negative predictive value was 84% and 64%, respectively.

No significant correlation between $V_{NEP_{0.5}}$ (in the supine position with NEP level of -5 cmH₂O) and AHI was observed in patients with OSAH ($r_s = -0.31$, $r_s^2 = 0.10$; 95%IC = -0.59 – 0.04). However, taking into account only the patients with severe OSAH (AHI ≥ 30), a significant inverse correlation was found between $V_{NEP_{0.5}}$ and AHI ($p < 0.05$; $r_s = -0.46$, $r_s^2 = 0.21$; 95%IC = -0.76 – -0.01) (Fig. 4).

Discussion

The present study indicates that during wakefulness OSAH patients when compared to snorers and controls have greater collapsibility of the upper airways which can be easily assessed looking at the early expiratory flow dynamics after NEP application during tidal breathing and properly measured as $V_{NEP_{0.5}}$ and V_{NEP_1} . Such measurements, however, are unable to distinguish on an individual basis apneic from non-apneic snorers because of the overlapping of the $V_{NEP_{0.5}}$ and V_{NEP_1} values between these groups of subjects. Nevertheless, our results provide support to the idea that a high degree of the upper airway collapsibility promotes OSAH, even if OSAH may

seldom occur in subjects with normal upper airway mechanics during wakefulness, suggesting the involvement of other pathogenetic factors.

Although our snorers had similar age, gender and BMI without obvious cranio-facial and ORL anomalies, lateral cephalometry or MRI studies of the pharynx were not performed, so we cannot exclude minor anatomic abnormalities in bony structure or soft tissue around the pharyngeal airway in OSAH patients. Conversely, careful inspection of the maximal and tidal expiratory flow-volume curves allowed us to rule out the presence of intrathoracic expiratory flow limitation during resting tidal breathing in all subjects. Therefore, we are confident that our subjects had no intrathoracic expiratory flow limitation which might have influenced the upper airway-related expiratory flow dynamics when NEP was applied.

The usefulness of the NEP method to assess the upper airway collapsibility was previously tested in 16 awake subjects known to suffer from sleep-disordered breathing.²⁷ In contrast to snorers, all patients with OSAH ($n = 8$) showed a substantial portion ($>30\%$) of the expiratory tidal volume throughout the NEP application (-5 cmH₂O, in the supine position) with lesser expiratory flow than the one recorded during the previous control tidal expiration.

Subsequently, in a group of 19 patients with OSAH when NEP was applied (-5 and -10 cmH₂O, in the supine position) the expiratory flow was reduced, when compared with the corresponding spontaneous expiratory flow, during a relevant part of the tidal expiration ($>20\%$) in those ($n = 13$) with a higher mean apnea-hypopnea index (AHI).²⁸

In these studies a significant correlation was found between the percentage of the tidal volume during the NEP application with lower expiratory flow than during the spontaneous breathing and oxygen desaturation index (ODI), in the former, and ODI and AHI, in the latter.^{27,28} Hence, the NEP method appeared suitable in order to detect an increased pharyngeal collapsibility in patients with OSAH during wakefulness and perhaps able to predict the severity of OSAH.

Recently, using the same criteria, a large cohort of snoring subjects was examined to assess the capacity of the NEP method to screen apneic from non-apneic subjects.²⁹ In this study a sensitivity of 81.9% and specificity of 69.1% in predicting OSAH was found when the expiratory flow during NEP (-5 cmH₂O in supine position) was below that of the previous control expiration for $\geq 27.5\%$ of the tidal volume. In addition, a significant correlation between NEP induced flow analysis and OSAH severity, as assessed by AHI, was found in the supine position using -5 cmH₂O of NEP with a coefficient value ($r_s = 0.51$) similar to the one we obtained in the severe OSAH patients ($r_s = 0.46$).

All of these studies, however, are based on the assumption that abnormal upper airway collapsibility is present or can be identified only when the expiratory flow during NEP becomes lower than the control one. Moreover, such finding has been erroneously taken as a marker of expiratory flow limitation. In contrast, an increased pharyngeal collapsibility can also be reflected by a smaller increase of expiratory flow during NEP. We believe that this flow has to be measured whether or not it is higher, lower or initially higher and then lower (or vice versa)

than the flow of the previous tidal expiration. Indeed, judging as abnormal (or quantifying the severity of) the upper airway collapsibility only by computing the percentage of the tidal volume where the expiratory flow during NEP application becomes lesser than the one exhibited in the previous expiration is a poorly reliable tool. This is because such measure is too dependent from the preceding control tidal breathing and because the expiratory flow profile is often erratic in the same subject during repeated NEP tests; in addition, several apneic patients do not show such phenomenon constantly.²⁷⁻²⁹ In order to overcome these problems, recently Tamisier and colleagues investigated a quantitative index corresponding to the ratio of the area under the expiratory flow/volume curves between NEP (-5 and -10 cmH₂O) and atmospheric pressure for the same tidal volume in awake subjects with sleep disordered breathing (SDB) and control subjects, both in supine and sitting position.³⁰ They found that this index was significantly different between controls and SDB subjects in all measurements, decreasing with the severity of the SDB. Moreover, in the supine position when -5 cmH₂O NEP was applied, a given threshold of this index had a positive predictive value of 88.6% and a negative predictive value of 80% to screen subjects with SDB. The Authors concluded that the NEP-related quantitative index may be useful to detect abnormal upper airway collapsibility in awake subjects with SDB. However, some limits of this study are obvious such as the lack of subjects with mild OSAH (AHI <15 and >5) and the age of the controls who were much younger (34 ± 12 yrs) than the patients with OSAH. Furthermore, the application of NEP near end expiratory lung volume tends to elicit reflex activation of genioglossus.²² This can unpredictably influence the area under the final part of the expiratory flow/volume curve during NEP both in controls and SDB subjects, affecting the quantitative index used to assess the upper airway collapsibility.

In a very recent paper Insalaco and coworkers used the drop of expiratory flow under NEP (ΔV -NEP), expressed as percentage change of peak expiratory flow under NEP, as index of upper airway collapsibility to detect OSAH in patients with sleep disordered breathing. Although this index was a better indicator of OSAH severity when compared to the previous ones, they reported, at best, a determination coefficient equal to 0.32 between the AHI and ΔV -NEP,³¹ using NEP of -10 cmH₂O in the supine position. An inherent problem with this approach is that ΔV -NEP does not take into account the duration of the expiratory flow drop under the NEP application, while it is very clear from the flow-time tracings given by the same Authors that this transient may last very differently with the same percentage value of reduction.

By time-integration of the expiratory flow in the first 0.5 and 1 sec after the application of a given level of NEP one can easily calculate the expiratory volume exhaled in a preset time in a given body position during wakefulness and use this parameter as an index of the mechanical properties of the upper airways at the onset of expiration when the genioglossus does not appear reflexively activated.²² Therefore, the novelty of this study is the utilization of a method which, still adopting the NEP technique, is more reliable to assess and measure the upper airway collapsibility because it is quantitative, and it is not influenced by the flow of the preceding tidal expiration and by the effect of neuromuscular factors.

$V_{i,NEP,0.5}$ and $V_{i,NEP,1}$ values were reduced in the supine position

at each level of applied NEP in all groups, likely to reflect a posture-related increase in the upper airway resistance.^{18,23,32,33} Therefore, $V_{NEP_{0.5}}$ and V_{NEP_1} measurements appear to be influenced by the baseline expiratory upper airway resistance which has been shown to be higher in OSAH patients, probably because of minimal structural abnormalities (abnormal hyoid bone position and increase in soft pharyngeal tissues)²⁰ and related shape changes. It is conceivable that lower $V_{NEP_{0.5}}$ and V_{NEP_1} found in our OSAH patients may be partly due to reduced baseline upper airway caliber which, on the other hand, is expected to increase the pharyngeal compliance and finally the upper airway collapsibility in these subjects.²¹ However, the expired volume in the first 0.5 or 1 sec was lower during NEP than during the previous control expiration in either position in about 15–18% of our apneic snorers. This never occurred in snorers and controls. This fact strongly suggests that in OSAH patients a brisk narrowing of upper airways is elicited by the sudden NEP application, the magnitude of which is largely depending on the pharyngeal collapsibility under the prevailing circumstances and substantially reflected by the $V_{NEP_{0.5}}$ or V_{NEP_1} values. In line with this reasoning, the early expiratory flow during NEP was often below the isovolume spontaneous expiratory flow, particularly in OSAH patients (see Fig. 1), as also shown in previous studies.^{22,27,28}

Under these experimental conditions, $V_{NEP_{0.5}}$ was significantly lower in apneic than in non-apneic snorers when measured in the supine position utilizing the smallest level of NEP (i.e.: -5 cmH₂O in our study). Thus, the lower the value of $V_{NEP_{0.5}}$ (or V_{NEP_1}), the higher the possibility for snoring people to have OSAH. Indeed, according to this method an increased pharyngeal collapsibility even during wakefulness affects the vast majority of snorers who have OSAH. This information is obtained in a rapid, simple and non-invasive way without cooperation of the subjects who can be studied when awake, repeatedly and in different body position. In this respect it has to be stressed that it is not necessary to control with regards to baseline spontaneous tidal volumes and flows. Indeed, $\Delta V_{NEP_{0.5}}$ and ΔV_{NEP_1} did not perform differently or better to distinguish between snorers and OSAH patients than $V_{NEP_{0.5}}$ and V_{NEP_1} .

Unfortunately, the ability to differentiate snorers with or without OSAH was not sufficient, at least within our capabilities, to recommend this technique and related parameters as a reliable diagnostic tool to obviate sleep studies or even to select subjects for polysomnographic evaluation. Lower levels of NEP (i.e.: -2 or -3 cmH₂O), however, might be more useful for this purpose and deserve to be tested in the future.

Three further comments need to be made. Firstly, generally a high collapsibility of the upper airways does not seem sufficient to cause OSAH since several snorers without OSAH exhibited similarly reduced values of $V_{NEP_{0.5}}$ or V_{NEP_1} . Secondly, other factors must influence the severity of OSAH, as assessed by ODI and AHI, because no different values of $V_{NEP_{0.5}}$ (or V_{NEP_1}) were found in any position or with different levels of NEP between mild-to-moderate and severe OSAH patients. Thirdly, some OSAH patients have surprisingly high values of $V_{NEP_{0.5}}$ (or V_{NEP_1}) comparable to those of the controls, showing a normal upper airway collapsibility during wakefulness, and thus suggesting different state-related factors leading to OSAH or a site of upper airway obstruction during sleep only at naso-pharyngeal level which cannot be directly assessed with this technique.

Finally, contrary to the opinion of the other authors who used the NEP technique to detect OSAH patients during wakefulness,²⁷⁻³⁰ we have to stress that, although the results obtained with $V_{NEP_{0.5}}$ were similar or even better than the previous ones,²⁷⁻³⁰ whatever NEP-related parameter is adopted, presently this tool is not sufficiently capable of revealing OSAH on an individual basis for clinical purpose.

In conclusion, the NEP technique when properly used is potentially useful to study upper airway collapsibility in patients with OSAH during wakefulness in order to better understand its main mechanisms, to assess in the long term the effects of various interventions, and possibly for selecting non-apneic snorers to follow up. On the other hand, it cannot be recommended for routine OSAH screening in awake snorers who should subsequently be subjected to sleep studies.

References

- 1 Isono S, Saeki N, Tanaka A, Nishino T: Collapsibility of passive pharynx in patients with acromegaly. *Am J Respir Crit Care Med* 1999, 160:64-68.
- 2 Isono S, Tanaka A, Sho Y, Konno A, Nishino T: Advancement of the mandible improves velopharyngeal airway patency. *J Appl Physiol* 1995, 79:2132-2138.
- 3 Isono S, Remmers JE, Tanaka A, Sho Y, Sato J, Nishino T: Anatomy of pharynx in patients with obstructive sleep apnea and in normal subjects. *J Appl Physiol* 1997, 82:1319-1326.
- 4 Isono S, Shimada A, Utsugi M, Konno A, Nishino T: Comparison of static mechanical properties of the passive pharynx between normal children and children with sleep-disordered breathing. *Am J Respir Crit Care Med* 1998, 157:1204-1212.
- 5 Liistro G, Stanescu D, Doods G, Veriter C, Aubert-Tulkens G, Rodenstein D: Hypopharyngeal and neck cross-sectional changes monitored by inductive plethysmography. *J Appl Physiol* 1990, 68:2649-2655.
- 6 Brown IG, Bradley TD, Phillipson EA, Zamel N, Hoffstein V: Pharyngeal compliance in snoring subjects with and without obstructive sleep apnea. *Am Rev Respir Dis* 1985, 132:211-215.
- 7 Schwab RJ, Geftter WB, Hoffman EA, Gupta KB, Pack AI: Dynamic upper airway imaging during awake respiration in normal subjects and patients with sleep disordered breathing. *Am Rev Respir Dis* 1993, 74:1385-1400.
- 8 Schwab RJ, Geftter WB, Pack AI, Hoffman EA: Dynamic imaging of the upper airway during respiration in normal subjects. *J Appl Physiol* 1993, 74:1504-1514.
- 9 Gleadhill IC, Schwartz AR, Schubert N, Wise RA, Permutt S, Smith PL: Upper airway collapsibility in snorers and in patients with obstructive hyperpnea and apnea. *Am Rev Respir Dis* 1992, 143:1300-1303.
- 10 Smith PL, Wise RA, Gold AR, Schwartz AR, Permutt S: Upper airway pressure-flow relationships in obstructive sleep apnea. *J Appl Physiol* 1988, 64:789-795.
- 11 Schwartz AR, Smith PL, Wise RA, Gold AR, Permutt S: Induction of upper airway occlusion in sleeping individuals with subatmospheric nasal pressure. *J Appl Physiol* 1988, 64:535-542.
- 12 Schwab RJ, Gupta KB, Geftter WB, Metzger LJ, Hoffman EA, Pack AI: Upper airway and soft tissue anatomy in normal subjects and patients with sleep disordered breathing. Significance of lateral pharyngeal walls. *Am J Respir Crit Care Med* 1995, 152:1673-1689.
- 13 Watanabe T, Isono S, Tanaka A, Tanzawa H, Nishino T:

- Contribution of body habitus and craniofacial characteristics to segmental closing pressures of the passive pharynx in patients with sleep-disordered breathing. *Am J Respir Crit Care Med* 2002, 165:260-265.
- 14 Haponik EF, Smith PL, Bohlman ME, Allen RP, Goldman SM, Blecker ER: Computerized tomography in obstructive sleep apnea. Correlation of airway size with physiology during sleep and wakefulness. *Am Rev Respir Dis* 1983, 127:221-226.
 - 15 Rivlin J, Hoffstein V, Kalbfleisch J, McNicholas W, Zamel N, Bryan AC: Upper airway morphology in patients with idiopathic obstructive sleep apnea. *Am Rev Respir Dis* 1984, 129:355-360.
 - 16 Anch AM, Remmers JE, Bunce H 3rd: Supraglottic airway resistance in normal subjects and patients with occlusive sleep apnea. *J Appl Physiol* 1982, 53:1158-1163.
 - 17 Stauffer JL, Zwillich CW, Cadieux RJ, Bixler EO, Kales A, Varano LA, White DP: Pharyngeal size and resistance in obstructive sleep apnea. *Am Rev Respir Dis* 1987, 136:623-627.
 - 18 Martin SE, Marshall I, Douglas NJ: The effect of posture on airway caliber with the sleep-apnea/hypopnea syndrome. *Am J Respir Crit Care Med* 1995, 152:721-724.
 - 19 Rodenstein DO, Doom G, Thomas Y, Liistro G, Stanescu DC, Culee C, Aubert-Tulkens G: Pharyngeal shape and dimension in healthy subjects, snorers, and patients with obstructive sleep apnea. *Thorax* 1990, 45:722-727.
 - 20 Verin E, Tardif C, Buffet X, Marie JP, Lacoume Y, Andrieu-Guitrancourt J, Pasquis P: Comparison between anatomy and resistance of upper airway in normal subjects, snorers and OSAS patients. *Respir Physiol* 2002, 129:335-343.
 - 21 Sforza E, Bacon W, Weiss T, Thibault A, Petiau C, Krieger J: Upper airway collapsibility and cephalometric variables in patients with obstructive sleep apnea. *Am J Respir Crit Care Med* 2000, 161:347-352.
 - 22 Tantucci C, Mehiri S, Duguet A, Similowski T, Arnulf I, Zelter M, Derenne JP, Milic-Emili J: Application of negative expiratory pressure during expiration and activity of genioglossus in humans. *J Appl Physiol* 1998, 84:1076-1082.
 - 23 Tantucci C, Duguet A, Ferretti A, Mehiri S, Arnulf I, Zelter M, Similowski T, Derenne JP, Milic-Emili J: Effect of negative expiratory pressure on respiratory system flow resistance in awake snorers and nonsnorers. *J Appl Physiol* 1999, 87:969-976.
 - 24 American Academy of Sleep Medicine Task Force: Sleep-related breathing disorders in adults: recommendation for syndrome definition and measurement techniques in clinical research. *Sleep* 1999, 22:667-689.
 - 25 Quanjer PT, Tammeling GJ, Cotes JE, Fabbri LM, Matthys H, Pederson OF, Peslin R, Roca J, Sterk PG, Ulmer WT: Lung volume and forced ventilatory flows. Report Working Party Standardisation of Lung Function Tests, European Community for Steel and Coal. Official Statement of the European Respiratory Society. *Eur Resp J Suppl* 1993, 16:5-40.
 - 26 Koulouris NG, Valta P, Lavoie A, Corbeil C, Chasse M, Braidy J, Milic-Emili J: A simple method to detect expiratory flow limitation during spontaneous breathing. *Eur Respir J* 1995, 8:306-313.
 - 27 Liistro G, Veriter C, Dury M, Aubert G, Stanescu D: Expiratory flow limitation in awake sleep-disordered breathing subjects. *Eur Respir J* 1999, 14:185-190.
 - 28 Verin E, Tardif C, Portier F, Similowski T, Pasquis P, Muir JF: Evidence for expiratory flow limitation of extrathoracic origin in patients with obstructive sleep apnea. *Thorax* 2002, 57:423-428.
 - 29 Van Meerhaeghe A, Delpire P, Stenuit P, Kerkhofs M: Operating characteristic of the negative expiratory pressure technique in predicting obstructive sleep apnea syndrome in snoring patients. *Thorax* 2004, 59:883-888.
 - 30 Tamisier R, Wuyam B, Nicolle I, Pepin JL, Orliaguet O, Perrin CP, Levy P: Awake flow limitation with negative expiratory pressure in sleep disordered breathing. *Sleep Medicine* 2005, 6:205-213.
 - 31 Insalaco G, Romano S, Marrone O, Salvaggio A, Bonsignore G: A new method of negative expiratory pressure test analysis detecting upper airway flow limitation to reveal obstructive sleep apnea. *Chest* 2005, 128:2159-2165.
 - 32 Jan MA, Marshall I, Douglas NJ: Effect of posture on upper airway dimensions in normal human. *Am J Respir Crit Care Med* 1994, 149:145-148.
 - 33 Yildirim N, Fitzpatrick MF, Whyte KF, Jalleh R, Wightman AJ, Douglas NJ: The effect of posture on upper airway dimensions in normal subjects and in patients with the sleepapnea/hyperpnea syndrome. *Am Rev Respir Dis* 1991, 144:845-847

Who Should Have A Sleep Study For Sleep Related Breathing Disorders?

L. Whiteford, P. Fleming, A. J. Henderson

By the time children are 5 years old more of their life will have been spent asleep than awake. Sleep medicine is therefore especially relevant in pediatrics. However, one recent survey showed that pediatricians' knowledge of sleep medicine is poor and that few pediatricians enquire about sleep as part of their general consultation.¹

Ventilatory function is physiologically reduced during sleep in adults and children. Therefore, respiratory disorders are exacerbated and may only be clinically apparent during sleep. Assessing respiratory status only when a child is awake will underestimate the severity of sleep related breathing disorders or miss them altogether. Such failure to recognize sleep related breathing disorders can have significant adverse consequences on children's physical health and on their behavior and learning.

How are sleep related problems identified? The first step towards identifying a sleep related breathing disorder is to take a careful history.

Symptoms during sleep and wakefulness should be enquired about as part of the general pediatric consultation (table 1). Symptoms of sleep disturbance are commonly reported by parents and include behavioural problems, parasomnias, and insomnia.² The commonest symptom associated with possible sleep disordered breathing is snoring, which may occur occasionally, only in association with upper respiratory infection or seasonal rhinitis, or on the majority of nights, termed habitual snoring. A history of snoring may be accompanied by reports of apnea or dyspnea associated with cessation of the respiratory noise. Such events are frightening to parents who may then maintain increased vigilance over their child during the night. Restless sleep with frequent changes of body position may indicate subcortical arousals.³ Children may sometimes adopt unusual sleeping postures, such as hyperextension of the neck to increase airway patency.

Autonomic disturbances, including heart rate variability,⁴ profuse sweating, and nocturnal enuresis,⁵ have been reported in children with sleep disordered breathing.

Children with breathing disturbances during sleep may be difficult to rouse or irritable on waking. Hypoventilation during sleep can be associated with the presence of morning headaches, vomiting, and lack of appetite for breakfast. Daytime symptoms include mouth breathing in children with adenoidal hypertrophy. Excessive daytime sleepiness is less common in children than in adults with sleep disordered breathing.⁶ However, behavioural disturbances such as hyperactivity or aggression may occur,⁷ and chronic sleep disturbance is associated with learning difficulties,⁹ developmental delay, failure to thrive, and cardiovascular dysfunction. Populations of children at increased risk of sleep related breathing disorders include those with adenotonsillar hypertrophy, craniofacial abnormalities, obesity, chronic respiratory or chest wall disease, and neuromuscular disorders affecting upper airway control and respiratory muscle function.

Physical examination should include assessment of factors predisposing to sleep related breathing disorders and of potential consequences of sleep disordered breathing. The former will include careful examination of the upper airway, looking particularly for signs of adenotonsillar hypertrophy, the commonest cause of increased upper airway resistance during sleep in children. Nasal patency should be assessed and the presence of craniofacial and palatal abnormalities noted. These include syndromes that affect the development of the mid-face and mandible, such as Pierre Robin, Apert, Treacher Collins, Charge, Goldenhar, and Pfeiffer,¹⁰ and conditions that may be associated with multifactorial sleep related breathing disturbances, for example achondroplasia,¹¹ in which central and obstructive apneas and chest wall restriction can all contribute to sleep related breathing disturbances. Children who have had palatoplasty for cleft palate may also have narrow posterior airways and be at risk of obstructive sleep apnea.¹² Respiratory examination, including measurement of respiratory function in appropriately aged children with suspected

The authors are with the Bristol Royal Hospital for Children, Department of Pediatric Respiratory Medicine & Sebastian Diamond Mother & Baby Sleep Laboratory, Bristol, UK. Reprinted from ADC Online, Arch Dis Child;89;851-855, © BMJ British Medical Journal.

Table 1 Reported features that may suggest a sleep related breathing disorder

Features during sleep	Snoring Witnessed apnoeas Cyanosis Parental concern about their child's breathing Restless sleep Unusual sleeping posture
Symptoms on waking	Difficult to rouse in the morning Irritability/bursts of anger on waking Morning headaches or vomiting Lack of appetite for breakfast
Daytime features	Mouth breathing Excessive daytime sleepiness Hyperactivity/behavioural disturbance Learning/memory difficulties Developmental delay Poor growth

pulmonary or chest wall disease should be performed. The contribution of neuromuscular diseases to sleep disordered breathing should be considered in children with disorders affecting muscle strength and tone, including cerebral palsy, congenital and acquired myopathies and muscular dystrophies, particularly in association with kyphoscoliosis, and disorders affecting control of upper airway tone and reflexes, such as bulbar or pseudobulbar palsy.

Potential complications of sleep disordered breathing include failure of expected growth.¹³ Cardiac examination is usually normal, although signs of pulmonary hypertension may be present. Systemic hypertension is probably less common in children than in adults with obstructive sleep apnea but has been described.^{14,15} Cor pulmonale was described in earlier studies but is uncommonly seen, possibly due to earlier recognition and intervention of severe obstructive sleep apnea.

Although clearly important, clinical history and examination alone are unable to differentiate between children with and without significant sleep related breathing disorders. Symptoms are common; the prevalence of habitual snoring in a general population of children is 10%.¹⁶ However, most habitual snorers will have primary snoring, characterised by the absence of associated hypoxaemia, hypercapnia, sleep disruption, or daytime symptoms. This is a benign condition that does not require treatment. Only a small proportion of children who habitually snore have obstructive sleep apnea requiring treatment. Therefore, attempts have been made to devise screening methods to identify children at risk of significant sleep related breathing disorders.

Brouillette and others¹⁷ designed a clinical scoring system based on three questions about breathing during sleep. When applied to a general pediatric population, this was able to discriminate between healthy children and those with severe obstructive sleep apnea syndrome (OSAS) but did not identify those with mild to moderate OSAS. Carroll and coworkers¹⁸ extended this scoring system and applied it to a population of children referred to a sleep clinic for assessment of snoring or difficulty breathing during sleep. In this setting it was not possible to reliably distinguish primary snoring from OSAS using the clinical history alone. Preutthipan and others¹⁹ studied parents' ability to predict the severity of childhood OSAS based on observation of their child's sleep. They showed that parents of

children with severe OSAS were more likely to report cyanosis, obstructive apneas, and extremely loud snoring. They felt the need to shake or watch their child more frequently during sleep and were afraid of their child's breathing at night. However, no single parental observation or combination of these could be used to confidently predict severe OSAS. Other investigators have also shown that clinical evaluation alone is not sufficient to identify children with significant sleep related breathing difficulties.^{20,21} A group at high risk for severe obstructive sleep apnea can be identified but milder degrees may be missed. Therefore, some form of sleep study is advisable for further evaluation of symptomatic cases.

What investigations are available?

Overnight polysomnography (PSG) in a sleep laboratory is considered to be the gold standard investigation for suspected abnormal breathing during sleep in children. A dedicated pediatric sleep laboratory, which can accommodate the unique needs of children, is the ideal setting for such investigations. Studies in adult laboratories may be suboptimal and will be misinterpreted if adult diagnostic standards are applied. Despite the fact that young children take frequent naps, PSG is best performed at night during natural sleep. Marcus and others²² reported that nap studies had a positive predictive value of 100%, but a negative predictive value of only 20% for sleep disordered breathing. Nap studies can be useful for screening but are of limited diagnostic value, as they may not include episodes of rapid eye movement (REM) sleep; the behavioural state during which abnormalities are most likely to be seen. There is also some evidence that a sleep study is more likely to be abnormal in the later part of the night, which would be missed by a nap study. Sedatives should not be used to induce sleep for PSG as they depress upper airway dilator muscle function and may induce worse apnea in children predisposed to OSAS.²³

PSG simultaneously records a number of physiological variables, which can be selected depending on the clinical context in which the study is being carried out. They typically include respiratory movements, gas exchange, cardiac rate and rhythm, sleep state, and muscle activity. Respiratory effort can be assessed by simultaneously recording chest and abdominal wall movement using inductance plethysmography. Paradoxical inward rib cage movement (PIRCM) during inspiration is associated with upper airway obstruction during sleep.²⁴ However, the usefulness of this measurement is limited in infants and young children, in whom paradoxical rib cage movements occur physiologically during REM sleep. A more accurate way of measuring respiratory effort utilises oesophageal pressure monitoring, but this is more invasive and the presence of an oesophageal manometer can interfere with sleep, making it unacceptable to many children. Airflow at the nose and mouth are seldom measured directly but proxy measures indicating the presence of gas flow, such as temperature change measured with a thermistor, can detect apneas. Oxygenation is measured by pulse oximetry, and carbon dioxide tensions can be measured non-invasively using an end-tidal CO₂ catheter or transcutaneous CO₂ electrode.

Sleep staging ensures that the study includes periods of REM sleep. It also allows arousals from sleep, including subcortical arousals, to be identified, and hence provides information on sleep quality. Staging sleep involves the combined measurement of the electroencephalogram (EEG), electro-oculogram (EOG)

to record rapid eye movements, and the electromyogram (EMG) to record submental and tibial muscle activity, thus allowing movement arousals to be detected. There is some debate about the value of precise sleep staging in the diagnosis of straightforward conditions such as obstructive sleep apnea in an otherwise healthy child with adenoidal hypertrophy, in which case quiet sleep can be differentiated from active sleep using cardiorespiratory and behavioral variables. Additionally, advances in technology, such as neural network analysis,²⁵ have the potential to simplify this process.

An audio video recording during sleep is usually performed as part of the PSG as it is helpful in correlating physiological disturbances with clinical or behavioural findings. A trained technician is required to supervise the study to assure quality. Therefore, PSG is expensive and time consuming to perform. Additionally, there are limited resources for full polysomnography in children in the United Kingdom and other countries. Therefore, researchers have been prompted to evaluate other options for the assessment of sleep disordered breathing either as diagnostic or screening investigations.

Pulse oximetry is the most widely used of the available screening methods. In some circumstances it can be useful, but it does have significant limitations. The finding of intermittent episodes of hypoxemia in a snoring child is highly suggestive of OSAS. Stradling and others showed that pulse oximetry had 93% sensitivity and 86% specificity for detecting OSAS.²⁶ Brouillette and others²⁷ showed a high positive predictive value for pulse oximetry but also a high false negative rate. Sleep related breathing problems are more likely to occur during rapid eye movement (REM) than during non-REM sleep. It is not possible to determine if adequate periods of REM sleep have been included in a sleep study using pulse oximetry alone. Some children who snore have significant disturbance in their breathing and sleep without recurrent episodes of hypoxemia. There is evidence that continuous partial airway obstruction may be the most common presentation of disordered breathing during sleep in children of all ages,^{28, 29} and this will not be detected by pulse oximetry. Additionally, pulse oximetry is not a reliable indicator of severity of OSAS.³⁰ This is potentially important in preoperative assessment, particularly of high risk children with adenotonsillar hypertrophy who have an increased risk of perioperative complications with severe disease. Pulse oximetry does however have an important role in assessing oxygenation during sleep in children with chronic lung disease and neuromuscular disorders.

Audio and video taping have also been used to screen for sleep disordered breathing. Recording the snoring sound can be used to detect apneas, but it cannot differentiate between central and obstructive apnea.³¹ Goldstein and colleagues³² found that a sound recording was positive when compared to PSG only 50% of the time. Lamm and others³³ found that home audiotapes were not sufficiently specific to reliably distinguish primary snoring from OSAS. A videotape of a child during sleep can provide useful information. It allows the physician an opportunity to observe disturbed sleep. However it is not practical in a clinical context to record and view more than a limited portion of the sleep period. The severity of sleep disordered breathing may vary throughout the night. The design of sophisticated computer systems for analysing video material may circumvent this problem. Combining audiotaping with pulse oximetry adds to the diagnostic value,³¹ however, lack of

arousal data and information to stage sleep remains a problem.

Due to the limitations of single channel recording systems, attempts have been made to develop simple multichannel devices that are suitable for unattended home use or with minimal supervision. There is limited evidence of the performance of these devices in children to date, but recent studies of such monitors compared in both laboratory and home conditions with PSG, have shown that obstructive apnea/hypopnea syndrome in adults can be diagnosed satisfactorily in a substantial proportion of cases.³⁴ Although such comparisons do not exist for children, unattended home PSG has been evaluated in a research context and found to provide acceptably high quality data.³⁵ Therefore, this represents a potentially useful and cost effective approach to the diagnosis of obstructive apnea in children that deserves further evaluation.

What abnormalities can be detected?

Obstructive sleep apnea and upper airway resistance syndromes: The most common indication for performing sleep studies in children is for the detection of obstructive sleep apnea syndrome (OSAS). OSAS in children is characterised by recurrent events of partial or complete airway obstruction during sleep, resulting in disruption in normal ventilation and sleep patterns,³⁶ but rarely with prolonged apnea. Episodes of obstruction occur primarily during REM sleep, in contrast with obstructive apneas in adults, which are mostly non-REM phenomena. The prevalence of OSAS in preschool children is estimated to be 1–3%.^{37,38}

The majority of cases of OSAS in children are associated with adenotonsillar hypertrophy. It is most commonly diagnosed between the ages of 2 and 8 years when the tonsils and adenoids are largest in relation to the upper airway size. However, the symptoms of OSAS are not simply related to structural narrowing of the airway by physical obstruction. This is supported by studies which have shown no correlation between upper airway or adenotonsillar size and OSAS,^{39,40} and by studies in which children have failed to show improvement after adenotonsillectomy despite the lack of other risk factors for OSAS.²¹ A combination of structural and neuromotor abnormalities is likely to be important for OSAS to develop. The role that these two factors have will vary in different individuals. In children with adenotonsillar hypertrophy, structural factors will tend to predominate, although subtle neuromotor abnormalities are likely also to be present.⁴¹ In children with cerebral palsy and neurodisability, it is more likely that neuromotor factors will be to the fore.

The classical picture of OSAS in which snoring is associated with obstructive apnea and hypoxemia represents only a small proportion of children with sleep disordered breathing. It is now widely recognised that a spectrum of abnormalities exists⁴² between primary snoring and classical OSAS, with two further conditions, upper airway resistance syndrome and obstructive hypoventilation being intermediate between the extremes. It is also recognised that children may move up or down this spectrum in response to seasonal variations and with age or growth. Therefore, these should not be regarded as static conditions. Upper airway resistance syndrome (UARS) is characterised by increased upper airway resistance and increased work of breathing during sleep sufficient to cause frequent microarousals (brief arousals, <15 seconds) from sleep,

which lead to excessive daytime sleepiness and diminished neurocognitive function. In obstructive hypoventilation, increased airway resistance sufficient to cause partial airways obstruction and hypoventilation occurs, leading to peak end tidal CO₂>55 mm Hg or end tidal CO₂>45 mm HG for more than 60% of the total sleep time. Snoring is common to all of these conditions. UARS and obstructive hypoventilation are not detectable using single channel screening, such as oximetry, but multichannel systems have the potential to identify obstructive hypoventilation and may also be useful in screening of UARS, the clinical significance of which has yet to be fully determined in children.

Other conditions: In children with chronic lung disease and limited pulmonary reserve, such as infants with chronic lung disease of prematurity and children with cystic fibrosis, the normal effects of sleep on respiratory function can result in significant ventilatory and gas exchange abnormalities.⁴³ Children may require higher inspired oxygen concentrations during sleep, whether or not supplemental oxygen is needed during wakefulness. These children can be identified by continuous assessment of oxygen saturation during sleep.

Children with neuromuscular disease, especially those with progressive conditions such as Duchenne muscular dystrophy, will eventually develop respiratory disturbances during sleep.⁴⁴ These are most pronounced during REM sleep due to diminished respiratory drive, atonia of the upper airway and intercostal muscles, and dependence of respiration on diaphragmatic function. Both obstructive apnea and alveolar hypoventilation can occur. Progressive scoliosis is often a contributing factor in these children. Mild hypercapnia and REM sleep desaturation are the first abnormalities to be observed and can be detected by combined recordings of gas exchange using oximetry and end tidal CO₂. Treatment is limited to supportive measures but these can prolong the duration and, most importantly, improve the quality of life for these patients.

Sleep studies will also identify conditions in which there is an underlying abnormality in the central control of respiration. These conditions may be primary, such as congenital central hypoventilation syndrome (CCHS), or secondary to diseases of the spinal cord or brain stem. CCHS may range in severity from mild alveolar hypoventilation during sleep with adequate ventilation during wakefulness to complete apnea during sleep and severe hypoventilation even when awake. Infants usually present with cyanosis and respiratory failure, or occasionally apnea at birth. Rarely, infants present later with apparent life threatening events or cor pulmonale. Definitive diagnosis requires careful evaluation using PSG, including measurement of ventilation during wakefulness, REM, and non-REM sleep states. Treatment of CCHS is with long term support of respiration. As ventilation requirements will change over time in such patients it is necessary that PSG should be repeated at regular intervals. It is our practice to do so on a six monthly basis.

Consequences of sleep disordered breathing in children

Failure to recognise sleep disordered breathing in children can have significant consequences on growth, cardiac, and neurological function. Early surveys of children with severe OSAS reported failure to thrive in 27–56% of cases.^{13,45} Increased recognition of OSAS and earlier intervention has made failure to

thrive the exception in recent times. However, children with OSAS still tend to have a growth spurt following adenotonsillectomy.⁴⁶ This would appear to be due to decreased work of breathing postoperatively rather than to increased caloric intake.⁴⁷ Two studies have suggested that endocrine factors may also have a role. Increases in insulin-like growth factor (IGF-1) and its binding protein have been shown after adenotonsillectomy in children with OSAS.^{48,49}

Recurrent nocturnal hypoxemia, hypercapnia, and respiratory acidosis can lead to pulmonary hypertension and on to cor pulmonale and congestive heart failure. This used to be a common presentation of OSAS in childhood but is now rarely reported. However, asymptomatic degrees of pulmonary hypertension may be more common than previously appreciated. Tal and others have shown reduced right ventricular ejection fractions in 37% of children with OSAS, although only 7% had clinical evidence of pulmonary hypertension.⁵⁰ All these children showed normalisation of heart function after surgery. Routine screening of children with suspected OSAS with ECG or echocardiogram is unlikely to be worthwhile.

Systemic hypertension is a common complication of OSAS in adults but less frequently reported in children. Marcus and colleagues found that children with OSAS had a significantly higher systemic diastolic blood pressure (but no difference in systolic pressure) than children with primary snoring.¹⁴ This observation raised concerns about the long term consequences to adult health of albeit mild increase of blood pressure during childhood associated with OSAS.

Children with sleep disordered breathing have been shown to have a high incidence of neurocognitive and behavioural disturbances.^{51–54} These include attention disorders, memory and learning disabilities, school failure, developmental delay, hyperactivity, aggressiveness, and withdrawn behaviour.⁸ Behavioral symptoms may be the primary clinical manifestation of sleep disordered breathing. Guilleminault and others showed that children aged 6 years and over who were referred to a sleep disorders clinic were frequently seen by the school counsellor before coming to the clinic, and concerns about attention deficit disorder and special educational needs had been raised.⁵² Rebellious behaviour was encountered more often than frank sleepiness. O'Brien and colleagues identified a high prevalence of sleep disordered breathing in children aged 5–7 years with mild attention deficit hyperactivity disorders (ADHD) compared with children with severe ADHD or none.⁵³

Further evidence for a link between behaviour and neurological symptoms and sleep disordered breathing comes from studies that have shown improvement in these symptoms after treatment with adenotonsillectomy.^{8,54} Gozal performed screening for sleep disordered breathing in first grade students who were performing in the lowest (10th) centile of their class. He found that a surprisingly high proportion (18%) were snorers with associated nocturnal gas exchange abnormalities. Children treated with adenotonsillectomy showed improvement in their grades the following year, whereas those left untreated did not.

Guidelines for referral and investigation of suspected sleep disordered breathing in children

The American Academy of Pediatrics has recently published clinical practice guidelines on diagnosis and management of

OSAS in children.⁵⁵ Although there are currently gaps in the evidence, the following is suggested as an approach to the recognition of OSAS in children:

(1) The possibility of obstructive sleep apnea should be considered in children with habitual snoring, although the majority of these children will have primary snoring. Although clinical assessment is poor at discriminating primary snoring from OSAS, symptoms or signs suggestive of the latter should prompt further investigation. In the presence of significant complications, such as cardiorespiratory failure, investigation should be urgent in a specialist center.

(2) Single channel systems, such as overnight oximetry, may be helpful if they show positive results in the context of a suggestive history of uncomplicated OSAS. However, a normal study does not exclude OSAS and polysomnography remains the gold standard investigation. Unattended home studies using multichannel systems appear promising and deserve further evaluation in this context.

(3) Complex and high risk patients, such as those with craniofacial abnormalities, neuromuscular disorders, and suspected central hypoventilation, should be referred to a specialist centre for further investigation.

References

- Owens JA. The practice of pediatric sleep medicine: results of a community survey. *Pediatrics* 2001;108:e51.
- Archbold KH, Pituch KJ, Panahi P, et al. Symptoms of sleep disturbances among children at two general pediatric clinics. *J Pediatr* 2002;140:97–102.
- Mogras MA, Ducharme FM, Brouillette RT. Movement/arousals. Description, classification and relationship to sleep apnea in children. *Am J Respir Crit Care Med* 1994;150:1690–6.
- Baharav A, Kotagal S, Rubin BK, et al. Autonomic cardiovascular control in children with obstructive sleep apnea. *Clin Auton Res* 1999;9:345–51.
- Brooks LJ, Topol HI. Enuresis in children with sleep apnea. *J Pediatr* 2003;142:515–18.
- Carroll JL, Loughlin GM. Diagnostic criteria for obstructive sleep apnea syndrome in children. *Pediatr Pulmonol* 1992;14:71–4.
- Dahl RE. The impact of inadequate sleep on children's daytime cognitive function. *Semin Pediatr Pulmonol* 1996;3:44–55.
- Gozal D. Sleep disordered breathing and school performance in children. *Pediatrics* 1998;102:616–20.
- Urschitz MS, Guenter A, Eggebrecht E, et al. Snoring, intermittent hypoxia and academic performance in primary schoolchildren. *Am J Respir Crit Care Med* 2003;168:464–8.
- Perkins JA, Sie KCY, Milczuk H, et al. Airway management in children with craniofacial abnormalities. *Cleft Palate Craniofac J* 1997;34:135–40.
- Mogayzel PJ, Carroll JL, Loughlin GM, et al. Sleep disordered breathing in children with achondroplasia. *J Pediatr* 1998;132:667–71.
- Rose E, Thissen U, Otten JE, et al. Cephalometric assessment of the posterior airway space in patients with cleft palate after palatoplasty. *Cleft Palate Craniofac J* 2003;40:498–503.
- Brouillette RT, Fernbach SK, Hunt CE. Obstructive sleep apnea in infants and children. *J Pediatr* 1982;100:31–40.
- Marcus CL, Greene MG, Carroll JL. Blood pressure in children with obstructive sleep apnea. *Am J Respir Crit Care Med* 1998;157:1098–103.
- Enright PL, Godwin JL, Sherril DL, et al. Blood pressure elevation associated with sleep related breathing disorder in a community sample of white and Hispanic children: the Tucson Children's Assessment of Sleep Apnea Study. *Arch Pediatr Adolesc Med* 2003;157:901–4.
- Ali NJ, Stradling JR. Epidemiology and natural history of snoring and sleepdisordered breathing in children. In: Loughlin GM, Carroll JL, Marcus CL, eds. *Sleep and breathing in children. A developmental approach*. New York: Marcel Dekker, 2000.
- Brouillette R, Hanson D, David R, et al. A diagnostic approach to suspected obstructive sleep apnea in children. *J Pediatr* 1984;105:10–14.
- Carroll JL, McColley SA, Marcus CL, et al. Inability of clinical history to distinguish primary snoring from obstructive sleep apnea syndrome in children. *Chest* 1995;108:610–18.
- Preutthipan A, Chantarojanasiri T, Suwanjutha S, et al. Can parents predict the severity of childhood obstructive sleep apnea? *Acta Pediatr* 2000;89:708–12.
- Wang RC, Elkins TP, Keech D, et al. Accuracy of clinical evaluation in pediatric obstructive sleep apnea. *Otolaryngol Head Neck Surg* 1998;118:69–73.
- Suen JS, Arnold JE, Brooks JL. Adenotonsillectomy for treatment of obstructive sleep apnea in children. *Arch Otolaryngol Head Neck Surg* 1995;121:525–30.
- Marcus CL, Keens TG, Ward SL. Comparison of nap and overnight polysomnography in children. *Pediatr Pulmonol* 1992;13:16–21.
- Biban P, Baraldi E, Pettennazzo A, et al. Adverse effects of chloral hydrate in two young children with obstructive sleep apnea. *Pediatrics* 1993;92:461–3.
- Kohyama J, Shiiki T, Shimohira M, et al. Asynchronous breathing during sleep. *Arch Dis Child* 2001;84:174–7.
- Shimada T, Shiina T, Saito Y. Detection of characteristic waves of sleep EEG by neural network analysis. *IEEE Trans Biomed Eng* 2000;47:369–79.
- Stradling JR, Thomas G, Warley AR, et al. Effect of adenotonsillectomy on hypoxaemia, sleep disturbance and symptoms in snoring children. *Lancet* 1990;335:249–53.
- Brouillette RT, Morielli A, Leimanis A, et al. Nocturnal pulse oximetry as an abbreviated testing modality for pediatric obstructive sleep apnea. *Pediatrics* 2000;105:405–12.
- Rosen CL, D'Andrea L, Haddad GG. Adult criteria for obstructive sleep apnea do not identify children with serious obstruction. *Am Rev Respir Dis* 1992;146:1231–4.
- Guilleminault C, Pelayo R, Leger D, et al. Recognition of sleep disordered breathing in children. *Pediatrics* 1996;98:871–82.
- Rosen GM, Muckle RP, Mahowald MW, et al. Postoperative respiratory compromise in children with obstructive sleep apnea: can it be anticipated? *Pediatrics* 1994;93:784–8.
- White JE, Smithson AJ, Close PR, et al. The use of sound recording and oxygen saturation in screening snorers for obstructive sleep apnea. *Clin Otolaryngol* 1994;19:218–21.
- Goldstein NA, Sculerati N, Walsleben JA, et al. Clinical diagnosis of pediatric obstructive sleep apnea validated by polysomnography. *Otolaryngol Head Neck Surg* 1994;111:611–17.
- Lamm C, Mandeli J, Kattan M. Evaluation of home audiotapes as an abbreviated test for obstructive sleep

apnea syndrome (OSAS) in children. *Pediatr Pulmonol* 1999;27:267-72.

34 Dingli K, Coleman EL, Vennelle M, et al. Evaluation of a portable device for diagnosing the sleep apnea/hypopnea syndrome. *Eur Respir J* 2003;21:253-9.

35 Goodwin JL, Enright PL, Kaemingk KL, et al. Feasibility of using unattended polysomnography in children for research: report of the Tucson Children's Assessment of Sleep Apnea study (TuCASA). *Sleep* 2001;24:937-44.

36 American Thoracic Society. Cardiorespiratory sleep studies in children. Establishment of normative data and polysomnographic predictors of morbidity. *Am J Respir Crit Care Med* 1996;160:1381-7.

37 Ali NJ, Pitson DJ, Stradling JR. Snoring, sleep disturbance and behaviour in 4-5 year old children. *Arch Dis Child* 1993;68:360-6.

38 Gislason T, Benediktsdottir B. Snoring, apneic episodes and nocturnal hypoxemia among children 6 months to 6 years old. An epidemiologic study of lower limit of prevalence. *Chest* 1995;107:963-6.

39 Fernbach SK, Brouillette RT, Riggs TW, et al. Radiologic evaluation of adenoids and tonsils in children with obstructive apnea: plain films and fluoroscopy. *Pediatr Radiol* 1983;13:258-65.

40 Mahboubi S, Marsh RR, Potsic WP, et al. The lateral neck radiograph in adenotonsillar hyperplasia. *Int J Pediatr Otorhinolaryngol* 1985;10:67-73.

41 Marcus CL, McColley SA, Carroll JL, et al. Upper airway collapsibility in children with obstructive sleep apnea syndrome. *J Appl Physiol* 1994;77:918-24.

42 Loughlin GM. Obstructive sleep apnea syndrome in children. Diagnosis and management. In: Loughlin GM, Carroll JL, Marcus CL, eds. *Sleep and breathing in children. A developmental approach*. New York: Marcel Dekker, 2000.

43 Gaultier C. Effects of breathing during sleep in children with chronic lung disease. In: Loughlin GM, Carroll JL, Marcus CL, eds. *Sleep and breathing in children. A developmental approach*. New York: Marcel Dekker, 2000.

44 Givan DC. Sleep and breathing in children with neuromuscular disease. In: Loughlin GM, Carroll JL, Marcus CL, eds. *Sleep and breathing in children. A developmental approach*. New York: Marcel Dekker, 2000.

45 Guilleminault C, Korobkin R, Winkle R. A review of 50 children with obstructive sleep apnea syndrome. *Lung* 1981;159:275-87.

46 Williams EF, Woo P, Miller R, et al. The effects of adenotonsillectomy on growth in young children. *Otolaryngol Head Neck Surg* 1991;104:509-16.

47 Marcus CL, Carroll JL, Koerner CB, et al. Determinants of growth in children with obstructive sleep apnea syndrome. *J Pediatr* 1994;125:556-62.

48 Bar A, Tarasiuk A, Segev Y, et al. The effect of adenotonsillectomy on serum insulin-like growth factor-I and growth in children with obstructive sleep apnea syndrome. *J Pediatr* 1999;135:76-80.

49 Nieminen P, Lopponen T, Tolonen U, et al. Growth and biochemical markers of growth in children with snoring and obstructive sleep apnea. *Pediatrics* 2002;109:e55.

50 Tal A, Leiberman A, Margulis, et al. Ventricular dysfunction in children with obstructive sleep apnea syndrome: radionuclide assessment. *Pediatr Pulmonol* 1988;4:139-43.

51 Ali NJ, Pitson D, Stradling JR. Natural history of snoring and related breathing behaviour problems between the ages of 4 and 7 years. *Arch Dis Child* 1994;71:74-6.

52 Guilleminault C, Pelayo R. Neuropsychological consequences of disordered breathing during sleep. In: Loughlin GM, Carroll JL, Marcus CL, eds. *Sleep and breathing in children. A developmental approach*. New York: Marcel Dekker, 2000.

53 O'Brien LM, Holbrook CR, Mervis CB, et al. Sleep and neurobehavioral characteristics of 5- to 7-year-old children with parentally reported symptoms of attention-deficit/hyperactivity disorder. *Pediatrics* 2003;111:554-63.

54 Ali NJ, Pitson D, Stradling JR. Sleep disordered breathing: effects of adenotonsillectomy on behaviour and psychological functioning. *Eur J Pediatr* 1996;155:56-62.

55 American Academy of Pediatrics. Clinical practice guideline: diagnosis and management of childhood obstructive sleep apnea syndrome. *Pediatrics* 2002;109:704-12.

Monitor the Long-Term Sleep/Wake Patterns of Children in Their Natural Environment...



...with Motionlogger Actigraph

Worn on the wrist, this device is rugged and waterproof. Recorded data can be analyzed for sleep/wake behavior and features include:

- Event Button
- Capable Run Time Over 30 Days
- Waterproof
- Status Verification
- Reliable Data Collection
- Supported by Experts
- Selectable Filter Ranges, Epoch Length, and Sensitivity



800.341.0066
 info@ambulatory-monitoring.com
 www.ambulatory-monitoring.com
 731 Saw Mill River Rd
 Ardsley, NY 10502-0609

Innovation from Compumedics



Quik-Cap PSG™

Place, Secure - Go!

Electrode Application System for Sleep Diagnostics

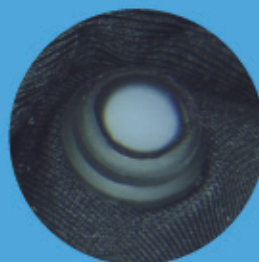
Quik-Cap PSG is a cap-based electrode application system customized for use in the diagnostic sleep environment. We've utilized our 8+ years of experience in building quality electrode caps for research and clinical EEG applications and created a versatile, cost effective tool that helps enhance all aspects of sleep lab productivity. Our new Quik-Cap PSG is designed to provide faster, more consistent electrode applications with easy clean-up thereby maximizing lab results and return on investment.



Only conductive gel and a blunt-tip syringe are required for fast set-up.



Unique blunt tip delivery helps part hair and obtain good impedance values.



Close-up of electrode cup shows reservoir with gel.

More innovative products from Compumedics:

Brain Research CURRY: Multimodal Neuroimaging Software



- Precise localization of Brain Activity
- Advanced Epilepsy Research Application
- EDF Format Compatible

NeuroMedical Supplies Consumables: EEG, PSG, Research and TCD



- Full line of accessories for Sleep & EEG
- Competitive pricing
- Monthly specials

EEG/Neurodiagnostics Siesta: Wireless EEG & PSG



- Wireless freedom
- 32 Data Channels
- EEG and PSG applications

Brain Research QuikCell: Liquid Electrode Delivery system



- Fast preparation
- Increased patient/subject comfort
- Fast easy clean up

AC880 - Issue 1

Since 1987, Compumedics Limited has emerged as a world leader in the design, manufacture, and sales of diagnostic sleep, neurophysiology, research and transcranial Doppler systems. Compumedics design expertise in the area of portable physiologic recorders and wireless data transmission is just one reason for our continued double digit growth in the USA year after year. Compumedics is improving people's lives through innovative products, exceptional service and a full range of consumables and accessories brought to you by dedicated people who care.

For more information please contact:

Headquarters, Compumedics Limited, Australia:
30-40 Flockhart Street
Abbotsford VIC 3067
Australia
Tel: +61 3 8420 7300
Fax: +61 3 8420 7399
Free Call: 1800 651 751

Compumedics USA Ltd:
7850 Paseo del Norte
El Paso
Texas 79912
Toll Free: 1 877 717 3975
Fax: 1 915 845 2965

Intelligent Ventilation

Get the free
simulation-CD



Designed for
100%
simplicity
and
patient safety.

The new
HAMILTON-G5.

Aren't there already more monitoring parameters available than most users ever need? The new HAMILTON-G5 ICU ventilator was designed to be simpler for the user and safer for the patient. Rather than bringing you even more curves and loops, its new Ventilation Cockpit™ integrates complex data into intuitive graphics that answer two essential questions:

- What is my patient's lung condition, and what kind of ventilation do they need?
- When should I take my patient off the ventilator?

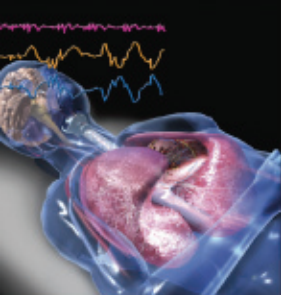
Aren't a dozen ventilation modes more confusing than helpful? The HAMILTON-G5 features ASV closed-loop control, providing easy-to-use and extremely safe ventilation for virtually all intubated patients, whether active or passive, and regardless of disease. ASV employs lung-protective strategies and tailors ventilation to your patient's specific needs.

Contact info@hamilton-medical.com or visit our website for more information and the free simulation-CD.

www.hamilton-medical.com/new

Pending FDA 510K.

HAMILTON
MEDICAL



SLEEP
MEDICINE

All sleep should be as good



*VIASYS is dedicated to helping patients
get a better night's sleep.*

VIASYS offers a range of innovative sleep apnea therapy solutions. These high quality product lines include patient interfaces and CPAP devices that are designed to enhance patient comfort and promote acceptance. Additionally, these products are easy to use and robust. VIASYS is also well known for its range of sleep diagnostic systems that are widely used in sleep disorders centers around the world. VIASYS is leading the way to better sleep.



VIASYS[®]
HEALTHCARE
Excellence For Life

800-231-2466
www.viasyshealthcare.com
TIARA Sales
800-582-7458
Intl. Sales +1 708-596-7784
fax: 216-521-1399

For information about Tiara please visit us at www.viasyshealthcare.com.



cobas[®]

Life needs answers

Now you won't have to do backflips to meet regulatory compliance.

Why? Because the **cobas b** 221 blood gas analyzer:

- ✓ Is the only analyzer with FDA 510(k) clearance for pleural fluid pH testing
- ✓ Provides innovative and reliable IT solutions for remote control, patient data management and QC reporting
- ✓ Features an extensive, labor-saving AutoQC[®] module with automatic lot-to-lot comparisons
- ✓ Offers eQAP, online CEU programs and remote troubleshooting capability

To find out more, contact your Roche Diagnostics representative or call 800-428-5076.



Diagnostics

COBAS, LIFE NEEDS ANSWERS, AUTOQC and EQAP are trademarks of Roche.
©2006 Roche Diagnostics. All rights reserved. 574-31643-0606

<http://us.labsystems.roche.com>