

Volume 4 Number 5 October-November 2009

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The Journal of Pulmonary Technique

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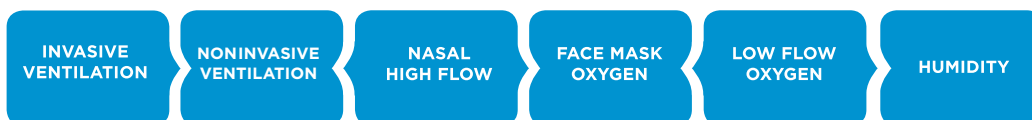
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Vol. 4 No. 5
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Editorial

Wrong Argument

Theodore Dalrymple writes in a recent editorial in the Wall Street Journal (a perfect place for this kind of foolishness): “If there is a right to healthcare, someone has the duty to provide it. Inevitably, that “someone” is the government. Concrete benefits in pursuance of abstract rights, however, can be provided by the government only by constant coercion.” He goes on to trash this so-called “right,” arguing that if this right is a duty to be provided, then so are others, such as food, shelter and clothing, and as such, the de-facto enforcement of, say, anti-overeating statutes. He says, “where does the right to healthcare come from? Did it exist in, say, 250 BC, or in AD 1750? If it did, how was it that our ancestors, who were no less intelligent than we, failed completely to notice it? How did it come into existence, and how did we come to recognize it once it did?”

He goes on to make a number of irrelevant and somewhat tendentious, factually dishonest arguments about healthcare in countries where it’s a “right,” as he sees it, eg, the UK. And, he says, if there’s a right to provide, there’s also a right to deny. Well, he can’t have it both ways, though he tries. In any event, he concludes, “There is no right to healthcare, any more than there is a right to chicken Kiev every second Thursday of the month.”

While these kinds of let them eat cake (or rather, let ‘em not) arguments are wearying at best, and leave a bad aftertaste with their needlessly callous tone, I would argue that Dalrymple’s argument is beside the point. Rather, I would say, if there’s going to be a government that provides basic services at a cost (that is, through taxation), then shouldn’t one of those services, indeed, the penultimate one, be healthcare? To put it simply, must we spend all our tax dollars on war and pork?

Shouldn’t we demand that our money be spent on something we can actually benefit from? This line of argument effectively bypasses the whole “rights” issue. Rights have always been indiscriminate and malleable. Really, the issue is more about fairness: where do we want our tax money spent, and don’t we get a say?

Les Plesko, Editor
Respiratory Therapy

PS: I would also note that Dalrymple is the pen name of Anthony Daniels, a British physician who is apparently touchy about the use of his real name. He is a contributor to the City Journal, Wall Street Journal, copyright 2009 Dow Jones & Company.

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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
Video website: www.rttv.ca

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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. All submissions may be emailed to s.gold4@verizon.net. 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.

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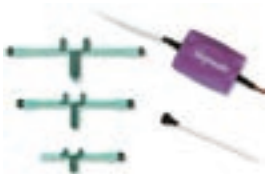
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* See, for example: Thille, A; Rodriguez, P; Cabello, B; Lellouche, F; Brochard, L; "Patient-ventilator asynchrony during assisted mechanical ventilation," Intensive care med., (226), 32:1515-1522, DOI 10. 1007/s00134-006-0301-8

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I'm a 27-year-old female that was diagnosed with severe sleep apnea about 2 years ago. I've been using nasal pillows and was ready for a new mask. My homecare company suggested the Swift for Her.

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I put the soft wraps on my mask and wow, what a difference that made. I woke up and there wasn't a line on my face!

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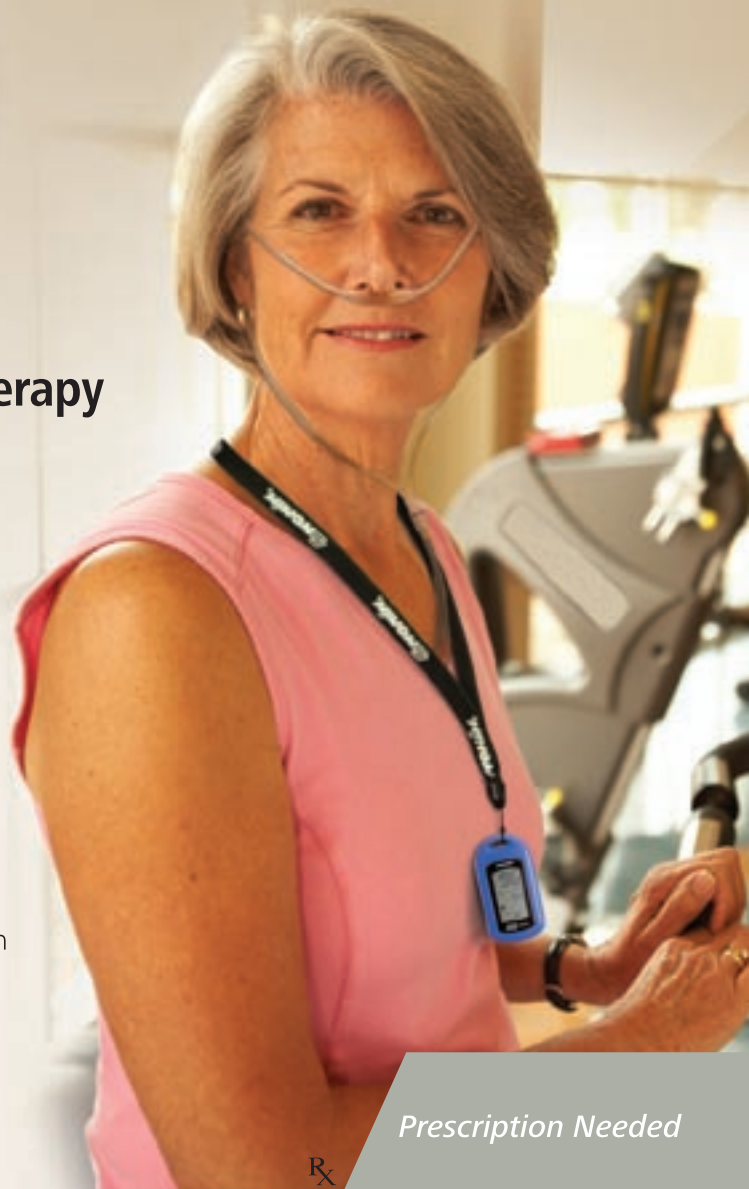
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News

□ October-November 2009

METHING AROUND

The New York Times reported on July 14 on former meth labs that were making their current occupants sick with respiratory ailments. A couple's three children had breathing problems and needed respirators, and one child had to be put a heavy dose of steroids. The mother came down with migraines, the father had kidney ailments. After five years in the house, the couple found out that their house, near Nashville, had been contaminated with methamphetamine from a lab on the premises. The cost to clean the house was pegged at \$30,000. Meth contamination permeates carpets, drywall, insulation and air ducts. The Feds say thousands of homes across the US may be contaminated. There's even a website, methlabhomes.com. There have been almost 7,000 meth labs discovered in the past year, a rise of 14%. Twenty states have laws requiring meth contamination cleanup, but all except Colorado hold the property owner responsible. The above is from the New York Times, "Illnesses Afflict Homes With a Criminal Past," by Shaila Dewan and Robbie Brown, July 14, 2009.

URGENT SURVEY

The HHS has contracted with AARC to perform a comprehensive inventory of mechanical ventilators in all of our nation's hospitals. The Office of Preparedness and Response is urgently requesting this inventory as the nation braces for the nH1N1 virus that may affect record numbers of Americans. Initial experience shows that many individuals are placed on ventilators as a result of this flu. With no accurate current accounting of the ventilators that would be available in a nationwide pandemic, the government is asking the AARC to immediately assist in performing a survey inventory. All information will be kept in confidence and it will not be available through the Freedom of Information Act. No relocation of ventilators will be performed; the information is sought so that the government can acquire or assist in augmenting current ventilator capacity. Information on filling out the surveys has been sent to each hospital in the US, addressed to the Manager of Respiratory Care. For more info go to aarc.org/nvs/.

WAO ASTHMA NEWS

World Allergy Organization featured the paper: Exploring the association between severe respiratory syncytial virus (RSV) infection and asthma (A). Does RSV cause A, or do those infants who later develop A have a genotype that both predisposes them to A and makes them more susceptible to severe RSV infection? That question is explored in this population-based study of hospitalization data from all Danish twins born alive between 1994 and 2000 (8280 twin pairs). The diagnosis of RSV infection was based on hospital diagnosis and/or RSV identification by ELISA. Presence of A was assessed by hospital discharge diagnosis and parental questionnaire. Among the children with

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RSV infections, 50% were hospitalized before the age of 6 mo and 75% before 12 mo. 95% had been hospitalized before 24 months. Twins hospitalized for RSV were more likely to have A. The data were subjected to statistical analysis and direction of causation (DOC) modeling. Monozygotic twins showed a higher correlation for A than dizygotic twins, suggesting a genetic component in disease susceptibility; but for RSV there was no such correlation, meaning that environmental factors play a larger role. When data were fitted to a DOC model, it was found that the best fit occurred for RSV infection resulting from the underlying susceptibility to A rather than vice-versa. Editor's comment: These data support the concept that RSV is associated with but does not cause A implying unknown genetic factors are involved. Thomsen SF et al, *Am J Resp Crit Care Med* 2009; 179:1091-1097. From the World Allergy Organization Journal July 2009, Volume 2, Issue 7 ISSN: 1939-4551. Contact worldallergy.org.

EAT YOUR VEGGIES

Boston University School of Medicine researchers say pregnant women who ate seven servings of fruit or vegetables every day reduced the risk of developing upper respiratory tract infections. Eating fruits and vegetables hadn't previously been associated with reducing the risk of URTIs in pregnant women. Researchers studied more than 1,000 pregnant women and found those who ate the most fruits and vegetables were 26% less likely to have URTI relative to those who ate the least. Neither fruit nor vegetable intake alone was found to be associated with the five-month risk of URTI. The patterns observed for total fruit and vegetable intake and either fruit or vegetable intake alone in relation to the three-month risk of URTI were consistent with those when assessing the five-month risk of URTI. Women in the highest quartile of fruit and vegetable intake had a stronger reduced three-month risk than the five-month risk of URTI. Moreover, there was a significant decreasing linear trend for the three-month risk of URTI with consumption of fruits and vegetables.

WINTER UNDER-LAND

Mortality from idiopathic pulmonary fibrosis and PF may be highest during the winter, according to researchers at the University of Colorado Health Sciences Center, who looked at death records from the National Center for Health Statistics. Results showed that mortality rates from PF varied significantly by season. The average mortality rate among all persons with PF was 17.1% higher in the winter, 12.7% higher in spring, and 5.2% higher in the fall than in the summer. See the full study in the July issue of *Chest*.

ANTI-ANTAGONISTIC

Long-acting β_2 -agonists may not have a clinically significant anti-inflammatory effect after all, according to researchers from McMaster University in Ontario. In a metaanalysis of 32 studies, researchers found that LABA therapy had no effect on sputum, bronchoalveolar lavage or mucosal inflammatory cell findings in adults or children. LABAs did decrease exhaled nitric oxide levels and BAL albumin levels in adults, suggesting a possible benefit.

A LONG BREATH

Respiratory problems in premies weighing in at under five and a half pounds persist into childhood and adulthood, according to a study by the University of Washington. Low birth weight survivors are at increased risk for long-term respiratory

disorders that are clinically significant and associated with increased healthcare utilization. The researchers used hospitalization records from a ten-year state database and selected as potential cases any person who was 18 years old at the time of hospitalization and linked these cases to birth weight data listed on birth certificates. They found that individuals with very low birth weight (less than 1.5 kg) or moderately low birth weight (1.5 to 2.5 kg) had an 83 and 34% higher risk of hospitalization for respiratory diagnoses. Those who had a history of very low birth weight had twice the risk of being hospitalized for asthma or respiratory infection and 2.6 times the risk of respiratory failure requiring mechanical ventilation. Researchers said low birth weight may account for over 22,000 adult hospitalizations per year, with charges in excess of \$225 million per year.

TRIGGER HAPPY

Instead of looking for a single trigger for allergens, a better way to avoid asthma may be to target a wide variety, according to The Cochrane Review. House dust mite reduction seems to be the most important intervention, and breastfeeding also showed some effectiveness. Researchers at Maastricht University Medical Center, in the Netherlands, analyzed nine studies that covered both inhalant and dietary types of allergen reduction, while six studies looked at one type of allergen reduction alone. In studies that included a dietary approach, mothers were encouraged to breastfeed or use special formula and to delay the introduction of solid foods into the child's diet. Environmental interventions included the reduction of dust mites, pet allergens and exposure to tobacco smoke in the child's immediate environment. However, genetics also play a likely part. People with a genetic susceptibility develop asthma more often if they are exposed to specific environmental influences. The environmental causes, however, are not totally clear. Studies suggest that if no parents had a history of asthma, there is a 6% chance of developing asthma. If one parent has a history, there's a 20% chance, and if both parents, there's a 40-60% chance that the child will have asthma, too. In other words, there is no one thing that is a consistently effective method of forestalling the condition.

RESP DOC DIES

Jere (Jeremiah) Mead, architect of the field of respiratory mechanics and Professor Emeritus in the Department of Environmental Health at the Harvard School of Public Health died on the Fourth of July at age 88, at a healthcare facility in Maine. In the '50s, Mead and his co-researcher Mary Ellen Avery, showed that fatal RDS in newborns was caused by abnormal surface tension in the lungs. Their discovery led to surfactant replacement therapy. In 1990, Mead was awarded the Edward Livingston Trudeau Medal by the American Lung Association in recognition of his career accomplishments. In 1996, he received the HSPH Faculty Emeritus Award of Merit.

FOR VAMPIRES ONLY?

Garlic pills may actually be good for fighting viruses, unlike the long list of useless "remedies," including vitamin C, various holistic supplements, and Zicam. A recent garlic study included 146 patients randomly assigned to take garlic pills or a placebo for 12 weeks. The number of days they were sick if they caught a cold decreased from five to less than two, reduced by more than half. There was also a dramatic reduction in the number of colds. But if it does work, how? Some laboratory investigations have suggested that some components of garlic

have antimicrobial properties that could kill the viruses that cause the common cold. Some researchers are skeptical of the results, saying that the findings from the included study could be a fluke or an outlier. In any event, one study does not make the case. Plus, garlic is a difficult research subject. There are a hundred different types, and each contains different compounds. In addition, the most active compound, allicin, isn't even in raw garlic, but forms in the mouth as the garlic is eaten. However, taking a garlic pill may stop allicin from forming, since it's killed by stomach juices.

DON'T FLY WITH ME

People with COPD can expect discrimination when they fly, according to a report from England. Very few airlines allow people to bring their own concentrator on board, or an oxygen cylinder. Instead, they insist that passengers should buy oxygen directly from the airlines, sometimes at huge cost. A British MP said this was blatant discrimination against disabled passengers and called on an end this practice.

DO-NOTHINGS

Few people changed their behavior in the early stages of the swine flu outbreak, according to a study at Psychiatry King's College London. Researchers conducted a telephone survey of 997 adults between May 8 and 12, 2009. Participants were asked nine questions about recent behaviors. The results suggested that, despite media coverage, public responses to swine flu were lackadaisical. Only 24% of the participants were worried about it, and just 2% said they were very anxious about it. Most people, 72%, said they didn't wash their hands more than before the outbreak, 83% didn't clean things better, and 85% didn't discuss what to do in case they got the virus. Less than 5% said they'd avoided people or places as a result of the outbreak. Many believed the outbreak and its possible results had been exaggerated and over-hyped.

SLEEP NEWS

LINKED

World Asthma Organization reports: Urine concentrations of cysteinyl leukotrienes (CysLTs) in children with obstructive sleep-disordered breathing (SDB). Adenotonsillar tissue from children (C) with SDB showed high levels of CysLTs and their receptors that may contribute to this disorder. C with SDB were compared to C with no evidence of SDB but with a history of recurrent tonsillitis. Subjects with asthma, respiratory tract infection or chronic inflammatory disorders were excluded along with those using antihistamines or intranasal corticosteroids. An obstructive apnea-hypopnea index (OAHI) was determined by overnight polysomnography and tonsillar size graded. Morning urine samples were assayed for CysLTs. A total of 92 C were enrolled and results were evaluated according to OAHI. C with OAHI ≥ 5 episodes/hr had significantly higher urine CysLT levels than those with mild or no SDB. Higher BMIs and larger tonsils were also predictors of SDB. These data support the hypothesis that SDB is associated with inflammation as well as anatomical factors, but whether the SDB is more severe because of the increased CysLTs or severe SDB causes an increase in CysLTs cannot be determined. Editor's comment: This study suggests that there is a link between SDB and inflammation. Kaditis AG et al, *Chest* 2009; 135:1496-1501. From the World Allergy Organization Journal July 2009, Volume 2, Issue 7 ISSN: 1939-4551. Contact worldallergy.org.

JUST YOUR TYPE

A study in the journal *SLEEP* identified an ECG-derived spectrographic phenotype, designated as narrow-band elevated low frequency coupling that is associated with prevalent hypertension, stroke, greater severity of sleep disordered breathing and sleep fragmentation in patients suffering from obstructive sleep apnea. Results indicate that the odds ratio for prevalent stroke was 1.65 in those with vs without the presence of e-LFCNB. The biomarker was detected in 1,233 participants (23.5%), with statistically significant differences between those with and without it. Patients with the biomarker tended to be older (average 64.7 years vs 61.4 years), male (63.3% vs 45.1%), slightly heavier (average BMI 29.3 versus 28.6) and sleepier (according to the Epworth Sleepiness Score test results). Sleep apnea severity and use of diuretics, calcium blockers, and B-blockers were associated with increased e-LFCNB. Only prevalent stroke remained associated with both categorical and continuous measures of e-LFCNB, while treated and total hypertension were associated only with the ECG biomarker as continuous measure. The ECG-based technique allows the coupling of breathing amplitude and heart-beat rate changes, which are both influenced by sleep, thus providing a map of sleep behaviors. Having the pattern suggesting a central or breathing control abnormality was associated with worse sleep, more severe sleep apnea, high blood pressure and an increased risk of prevalent strokes. Therefore, OSA patients who are at increased risk for high blood pressure may be at even greater risk if they also have a control abnormality. The cross-sectional retrospective study obtained polysomnographic and clinical data from 5,247 patients. The ECG-derived spectrogram's detection of periodic breathing-type respiratory oscillations exceeded that identified by visual detection of periodic breathing.

NEWS FEATURE

ABGs as Extubation Criteria

Melissa Turner, BA, RRT

When managing mechanically ventilated patients, the goal is to attempt a Spontaneous Breathing Trial (SBT) as soon as possible once the patient is ready so that liberation from the ventilator can be realized. It has been found that weaning protocols are effective in achieving this goal. Respiratory therapists use simple screening guidelines to identify patient readiness. Evidence-based guidelines for weaning and discontinuing ventilator support list Arterial Blood Gases (ABGs) as objective criterion for successfully completing SBTs.

The study done by Pawson et al¹ used weaning protocols which did not include ABGs and only used ABGs at the discretion of the attending physician. The details of this particular weaning protocol can be found in Figure 1. This study performed a retrospective chart review of patients extubated between the dates of July 1, 2002 and July 1, 2003. Extubation failure is defined as a required re-intubation within forty eight hours of extubation. The use of NPPV after extubation was not considered as an extubation failure.

Within the study by Pawson et al, 54 extubations were identified. Of those, 35 (65%) were performed without an ABG being performed after an SBT. Of those 35, there were 3 failures, which

is equal to a success rate of 94.3%. The 19 other patients that were extubated did have an ABG performed following the SBT and had 1 extubation failure. The success rate for this group was 94.7%. For both groups, the success rate was the same. Some differences noted were that the duration of mechanical ventilation was shorter in the first group (no ABG), but there were no statistical differences in age or diagnosis of COPD or presence of more severe hypoxemia between the 2 groups.

Mechanically ventilated patients must have acceptable oxygenation and ventilation before attempting SBT as well as having acceptable gas exchange in order to pass an SBT. The ABG is the standard for evaluating gas exchange. Using the ABG as a predictor of extubation success has not been studied. The general expectation is that ventilated patients should have a fairly normal pH before and during an SBT. For this study (patients that did have an ABG performed), 3 patients had a pH < 7.3, and 5 patients had a pH > 7.5. All 8 of those patients were successfully extubated. The 3 patients that failed extubation had a normal pH.

Salam et al² showed in a study that ABGs did not change the management or decision to extubate in 93% of patients when added to the clinical assessment. In this study, it was also admitted that those patients where the ABGs played a role in the decision not to extubate may have been successful if given the chance. Salam et al² also made a point that the costs would be more if a patient who is ready to be extubated is not extubated. It was noted that the risk of leaving a patient intubated is more than having to re-intubate a patient that fails trial.

ABGs are important in managing mechanically ventilated patients, but using them as an outcome predictor of extubation is still in question. ABGs have influenced decision making regarding extubation in a small minority of patients. The appropriateness of using ABGs routinely as a component of weaning protocols is certainly questioned and further research is required to determine minimally acceptable criteria for gas exchange in certain patient populations.

Amoateng-Adjepong Y, Manthous CA. The effect of arterial blood gas values on extubation decisions. *Respir Care* 2003; 48(11): 1033-1037.

Editorial comment Paul Garbarini MS, RRT, Clinical Manager Hamilton Medical.

Melissa Turner's article brings to mind some empirical experience from my past. ABGs in patients failing weaning trials with some frequency demonstrate hypercapnea. However, clinical signs such as accessory muscle use or increasing rapid shallow breathing index are readily apparent prior to decompensation in AGBs. Many patients failing wean trials may have normal ABGs. I actually dreaded the post extubation "normal" ABG call to the resident, as often the patient's work of breathing and respiratory pattern clearly evidenced impending respiratory failure. Yet the "good ABG vetoed my attempts to discontinue the weaning trial until the need for re-intubation became a respiratory arrest stat call.

A study on surgical patients requiring mechanical ventilation for 72 hours reported respiratory fatigue occurring in 1/3rd of patients undergoing a spontaneous weaning trial. A recent study on 500+ patients of mixed diagnosis reported that 40% of ventilated patients fell into the ATS/SCCM consensus guideline definition of difficult to wean or prolonged weaning (both groups requiring multiple weaning attempts). EBM supports the concept of frequent wean screens leading to spontaneous breathing trials. As we implement EBM guidelines and enter the age of automated weaning through closed loop ventilation systems, it's apparent that clinical assessment skills are still critical in decision making as patients failing wean trials are subject to increased morbidity and mortality.

PRODUCTS

PUT IT IN WRITING

Airos Consulting provides freelance writing services for respiratory care industry magazines, periodicals and educational courses. Airos Consulting is a Missouri-based respiratory care industry writing service that has been published in several industry periodicals and magazines. The consulting service is operated by Aimee Staggenborg, MA, BA, RRT, a professional, registered respiratory therapist, who also serves as primary medical writer for Airos. The company provides medical and clinical consulting, clinical educational course and article writing, clinical and medical research, logistics consulting, compliance and industry protocol writing, and professional development writing for respiratory care professionals and other medical organizations. Topics covered in recently published articles and educational courses include:

- Nutritional needs for COPD patients
- Professional and career development for RRTs
- Improving CPAP compliance
- Best practices in respiratory care
- Restrictive lung disorders
- Medical gases therapy
- Protocol and clinical practice guidelines
- Emergency preparedness.

Aimee Staggenborg's article, *Getting Involved*, appears on page 29 in this issue. She has also recently published articles in *Advance Magazine for Respiratory Care*. The magazine is an

Intensive Care Unit Ventilator Weaning Protocol

Patient Screen

- PaO₂/FiO₂ ratio ≥ 150 mmHg on FiO₂ ≤ 0.50 and PEEP ≤ 5 cmH₂O
- Minute volume ≤ 15 L/min
- Mean arterial pressure ≥ 60 mmHg while off vasopressors
- No continuous infusions of sedative/analgesics, with exception of propofol
- Adequate cough/does not require suctioning more than every 2 hr
- Awake and follows simple commands

Spontaneous Breathing Trial

- If patient meets all above criteria, place patient on pressure support of 10cmH₂O and PEEP 5cmH₂O and current FiO₂

Spontaneous Breathing Trial Failure

- SpO₂ drops $\leq 90\%$
- Respiratory rate consistently ≥ 35 breaths per minute
- Heart rate changes by $\geq 20\%$ in either direction
- Clinical respiratory distress (eg, accessory muscle use or diaphoresis)

If Patient Tolerates Spontaneous Breathing Trial for 2 hr

- Contact medicine resident to determine whether to:
 - * extubate
 - * leave patient on SBT
 - * return to original ventilation mode

Figure 1.

References

- 1 Pawson SR, DePriest JL. Are blood gases necessary in mechanically ventilated patients who have successfully completed a spontaneous breathing trial. *Respir Care* 2004; 49(11): 1316-1319.
- 2 Salam A, Smina M, Gada P, Tilluckdharry L, Upadya A,

industry leader specializing in respiratory and sleep medicine. It features articles about clinical, technical and business management trends for professionals in pulmonary, respiratory care and sleep medicine. Aimee Staggenborg is a frequent contributor to RC Educational Consulting Services, providing educational courses approved by the AARC. She is a volunteer therapist for Wings of Hope. To contact Airos Consulting, Inc and Aimee Staggenborg, MA, BA, RRT, you can e-mail airosconsulting@hotmail.com or call the Airos Consulting offices at (636) 294-6772.

GOING 4-WARD

Discovery Labs announced the results of its latest meeting with the FDA regarding Surfaxin (lucinactant) for the prevention of RDS in premature infants. The meeting was convened to discuss resolution of the remaining issue necessary for marketing approval and focused on the Surfaxin fetal rabbit biological activity test. The FDA stated that it would apply a newly-refined standard to determine whether Discovery Labs has adequately demonstrated the comparability of Surfaxin clinical to commercial drug product. The FDA insisted that data generated from the preterm lamb model study and BAT studies must demonstrate the same relative changes in respiratory compliance, and that it believed such a demonstration would present Discovery with a high hurdle. In light of this new standard, Discovery is now focusing on maximizing the inherent value of its KL₄ surfactant and aerosolization platforms and will minimize development risk by leveraging Surfaxin's established proof-of-efficacy in RDS. The two highest priority programs are Surfaxin LS and Aerosurf. The synthetic nature and formulation flexibility of KL₄ supports expansion into a wide range of respiratory disease conditions. Discovery Labs intends to pursue these opportunities through strategic alliances. While proceeding with BAT as a validation method, Discovery believes that the best way to address the global RDS patient population is to advance its KL₄ surfactant programs and target traditional endotracheal tube delivery and less invasive surfactant administration through aerosolization. Aerosurf may provide benefits that will advance the management of RDS and represent a significant improvement from a medical and economic perspective. As for Surfaxin approval, Discovery Labs may further interact with the FDA to assess whether Surfaxin approval can be gained without additional clinical trials, or may exercise its right of appeal through the FDA's Formal Dispute Resolution process. In addition to focusing on Surfaxin LS as a KL₄ formulation and Aerosurf, Discovery Labs had initiated exploratory development programs targeting ARF, ALI, CF, and the feasibility of drug combination therapies utilizing KL₄ surfactant. Contact discoverylabs.com.

HONORS

Royal Philips Electronics recently partnered with Aerocare Paul Home Oxygen Service of Greeley, CO to lend EverGo portable oxygen concentrators to the Honor Flight Network, a non-profit organization created solely to honor America's veterans. The Network transports veterans to Washington, DC to visit and reflect at their memorial, with priority given to World War II survivors and veterans who may be terminally ill. On April 27, 134 veterans flew from Denver for a two-day tour of the capital's monuments and sights, including the World War II Memorial, the Marine Corps War Memorial, and the Korean and Vietnam memorials. Don Paul of Aerocare Paul Home Oxygen Service coordinated the loan and set up of the EverGo portable oxygen concentrators for eight of the travelers who are dependent

on supplemental oxygen. Portable oxygen concentrators like EverGo, which offers a unique 8-hour battery life, make air travel easier for individuals who require oxygen. The Respironics EverGo is one of a handful of Federal Aviation Administration-approved portable concentrators now permitted for use aboard commercial airline flights in the US.



Ervin Schlepp served on the USS Ranger from 1943-45 as a Seaman First Class and worked as part of the deck fire crew.



Dale Peterson served as a firing battery commander in Italy from 1943-45.

FULL SPECTRO

Smiths Medical announced the launch of its new BCI SPECTRO₂ Pulse Oximetry Portfolio. Designed for a variety of patient care settings, the portfolio features three models: the SPECTRO₂ 1 10, SPECTRO₂ 1 20, and SPECTRO₂ 1 30 Pulse Oximeters. The SPECTRO₂ Pulse Oximetry Portfolio is built on a foundation of proprietary BCI technology and delivers accurate, trustworthy readings across a full range of patient care settings—even during motion or low perfusion conditions: SPECTRO₂ 1 10 Pulse Oximeter is designed with the durability and dependability associated with the BCI brand, and delivers reliable results in primary care environments at an affordable cost. SPECTRO₂ 1 20 Pulse Oximeter features patented BCI serial autocorrelation technology which allows it to deliver reliable spot-check results in some of the most challenging clinical settings, including those with the presence of low perfusion or motion. SPECTRO₂ 1 30 Pulse Oximeter has all the benefits of the other two models, plus multiple operating modes with audible and visual alarms, and the availability of a nurse call system that alerts healthcare providers for potential clinical intervention to ensure patient safety. With its unique features and optional accessories, this BCI family of pulse oximetry devices facilitates improved patient care and clinical efficiency, while providing the flexibility and convenience required by today's healthcare professionals. The portfolio's array of accessories makes it possible to customize

a solution to suit each environment's specific needs. Features include: on-board cradle to store and protect the sensor, new BCI spot check finger sensor, pulse amplitude index bar graph indicator, memory storage for up to 99 patients, large and bright LED display, and a three year warranty. Contact smiths-medical.com.

LIFELINE

What is the Oxy-Lifeline and how does it work? The Oxy-Lifeline, from Certified Medical Sales, is a rapidly deployable system that can supply your facility with uninterrupted service by taking advantage of gas supplies that you already have on site. The Oxy-Lifeline will allow your facility to operate as normal in an emergency without straining available manpower by having to relocate patients, or rely on suppliers with portable tanks that may be hours away. The Oxy-Lifeline can be deployed in minutes by 1-2 personnel. It can supply uninterrupted service while repairs are made to your main line. For pricing or product demonstration call (800) 537-3090, or contact certifiedmedicalsales.com.

REFORM SCHOOL

Siemens Healthcare announced that Thomas Miller, Chief Executive Officer (CEO) for the Workflow & Solutions Division, testified before the Health Subcommittee, Committee on Energy and Commerce, US House of Representatives on the need for healthcare reform. During the hearing, Comprehensive Health Reform Discussion Draft, Day 2, Miller testified on ways to improve the quality of healthcare delivery while reducing its overall costs. He noted that there is undeniable evidence that medical imaging finds disease earlier, renders some invasive procedures obsolete, and saves lives. The medical imaging industry has worked hard to generate savings and efficiencies by developing physician-driven appropriateness guidelines that will ensure appropriate and effective use of diagnostic technologies, while assuring every patient has access. Miller presented to the Committee the facts about medical imaging: Diagnostic technologies support more cost-effective care by enabling earlier, faster and more accurate diagnosis, eliminating the need for expensive and invasive surgeries and inappropriate therapies, reducing hospital admissions, and, in many cases, avoiding costs of long-term chronic conditions. The growth in medical imaging can be attributed to its transformational effect on medicine for almost every facet of every disease. Physicians know that medical imaging is simply the best tool they have to diagnose disease with confidence. And, the great majority of physicians have one overriding interest: to achieve the best possible outcomes for their patients. The best means to reduce costs and overuse is by creating a more efficient healthcare system through Healthcare Information Technology and to manage medical imaging utilization through physician-driven appropriateness guidelines. Contact usa.siemens.com.

SOFTWARE

Siemens Healthcare announced the launch of its newest version of Inveon Research Workplace, IRW 3.0. This new software provides Inveon users with an expanded set of tools for image visualization and data analysis, and new solutions for important applications in cardiac PET imaging. As part of Siemens' ongoing commitment to preclinical imaging solutions, this new software is one more tool in the comprehensive array of solutions offered with Inveon hardware and software technology for preclinical research. The new IRW 3.0 software is equipped with image visualization, analysis and data management features that

increase overall ease-of-use. IRW 3.0 enables visualization and analysis of dual-gated dynamic PET data. With support for both acquisition and analysis of these types of data, Inveon users are able to carry out complex and demanding preclinical studies which are affected by cardiac and/or respiratory motion artifacts. In addition, IRW 3.0 allows for quick and accurate high resolution image data export, representation and interpretation, while delivering features such as arbitrary image reorientation and image filtering. Inveon•Workplace also provides improved kinetic modeling and parametric analysis tools. Contact usa.siemens.com.

REVOLUTIONARY

GEM Premier 4000 is the revolutionary analyzer (BG, Electrolytes, Metabolites, Glu, Lac, Hct, tHb, O₂Hb, COHb, HHb, MetHb, sO₂, BUN*, Creat*, Total Bili*, HCO₃* [*in development]) with integrated CO-Oximetry that quickly provides consistent, accurate, lab-quality results throughout your hospital. Easy-to-use, touch-screen displays make it simple to select and customize parameters. Self-contained cartridges incorporate all components for patient testing and are maintenance-free. iQM automates quality control and continuously detects, corrects and documents to assure quality results and compliance, 24/7, regardless of operator or testing location. GEMweb Plus software enables remote access to any networked analyzer for real-time status updates and supervision of remote locations. Contact ilww.com.

PASSIONATE

Instrumentation Laboratory presented the "Passion & Results" Award to three recipients at the Congress for the International Society on Thrombosis and Haemostasis (ISTH) and at the Annual Meeting for the American Association for Clinical Chemistry (AACC), held in Boston and Chicago. The "Passion & Results" Award was established to honor healthcare providers who have demonstrated true passion for their profession, resulting in improved patient care. The winners received the award plus a \$2,000 educational grant for their institution.

NEW BOSS

Michael Reitermann has been appointed the new CEO of Siemens Healthcare's US organization. Reitermann will lead the marketing, sales and service functions for Siemens Healthcare in the US, including the medical imaging, therapy and healthcare information technology businesses. He will be based at the US headquarters in Malvern, PA. Reitermann worked as a senior project manager at the corporate strategies division as well as a partner in Siemens Management Consulting. He also served as vice president for sales, marketing and innovation of the Siemens Angiography, Fluoroscopy and X-ray business unit. Most recently, as CEO of Siemens Molecular Imaging (MI) Business Unit, and president of the former Nuclear Medicine division, he was responsible for the establishment and implementation of MI's business objectives around the world.

NOT A FLUKE

Fluke Biomedical offers a used-equipment discount purchase program. Fluke Biomedical's used equipment purchase program allows customers to purchase like-new equipment from their demonstration-showcase inventory, some models less than a year old, at a fraction of new-product cost. Customers who take advantage of this program enjoy the same new-product warranty as all Fluke Biomedical equipment, fresh calibration, and the benchmark quality of design only available from Fluke

Biomedical. The company also announced its improved website, which features enhanced search capabilities, progressive user interface, and a pleasant and efficient customer experience. Contact flukebiomedical.com.

ICONIC

Dräger Medical Inc has announced its enhanced collaboration with Intensive Care Online Network (ICON) to provide 24/7 clinical and educational support for Dräger ventilation equipment to include Carina Ventilator Customers. ICON has supported Dräger Evita Series ventilator customers in the US and Canada beginning in September 2001 and has since extended support to Savina and Babylog ventilator customers. The Carina now follows this tradition of exceptional, one of a kind clinical support for customers. ICON uses telephone and the latest web technology to connect Dräger customers to a multi-professionally staffed Critical Care Resource Center which provides immediate live support for users of Dräger Evita, Savina, Babylog 8000+ and, now, Carina ventilators. ICON clinicians are certified and trained in the use of these Dräger ventilators and are available 24x7 to answer questions about the equipment, assist in troubleshooting alarms and help guide ICU staff through critical ventilation issues. ICON clinicians can even be contacted via live video, enabling uni- or bi-directional visual and audio interaction between ICU staff and the ICON team. ICON's multi-professional staff includes intensive care physicians, pulmonologists, critical care nurses, respiratory care practitioners, critical care pharmacists, registered dietitians and information technology specialists. Dräger customers can receive around-the-clock support from ICON clinicians while continuing to manage patients at the bedside. ICON provides customer care packages through their website's E-learning Center. Subscribers also have access to on-line clinical documents and case studies, educational web conferences, symposiums with continuing education units and respiratory care modules for RCPs and registered nurses. "This relationship enables Dräger to provide an elite level of clinical education and support that is not available from other ventilator vendors. ICON provides the 24/7 clinical support from simple troubleshooting to the most critical of issues," said Ed Coombs, MA, RRT, Director of Marketing for Ventilation, Dräger Medical, Inc. Contact draeger.com.

CLEARED FOR TAKEOFF

Hamilton Medical, Inc announced FDA 501(k) market clearance of the Hamilton Medical C2 Ventilation System. The Hamilton C2 is designed for adults and children requiring invasive or non-invasive ventilation support. With its compact design, a weight of only 19.5 lbs, built-in batteries and an ultra-quiet turbine, this ICU ventilator can accompany your patient anywhere within the hospital, independent of central gas and power supplies. You do not have to disconnect a patient for transport, thus increasing patient safety and comfort, while at the same time reducing your workload. Hot-swappable batteries permit extended ventilator operation for a virtually unlimited period of time. The touch screen provides easy operation and clear data display. The compact design of the Hamilton C2, the integrated blower and innovative battery management make the Hamilton C2 the perfect choice for patient transport inside the hospital. It is no longer necessary to change the ventilator for transports, which provides for continued patient improvement, as the C2 is a transport and a true critical care ventilator. Two batteries, fully charged, allow the Hamilton C2 to run for up to five hours without AC power. The Hamilton C2 can run indefinitely on battery power. The optional universal bed trolley is a comprehensive solution

for mounting the patient monitoring system, perfusion pumps and the Hamilton C2 to the bed. Synchrony between patient and the ventilator is one of the main issues in ventilation. Using patient proximal flow measurement, the C2 and all Hamilton Medical ventilators perfectly adapt to the patient's needs. The C2 supports the patient in all conventional volume and pressure controlled modes. The biphasic concept allows the patient to breathe freely at anytime. Part of Hamilton Medical's Intelligent Ventilation strategy is ASV (Adaptive Support Ventilation), an innovative mode that is able to adapt to the patient's lung mechanics. Breath by breath, the patient's resistance and compliance are measured, evaluated and visualized in the Dynamic Lung panel. In an effort to facilitate and improve patient weaning, the innovative Ventilation Status panel provides the user an overview of patient-ventilator dependency at a glance. Non-invasive ventilation is used more often as an alternative to intubation and conventional ventilation. NIV addresses well known complications such as, but not limited to, trauma during intubation, infections and is more comfortable for the patient. The use of NIV is not trivial and some precautions have to be taken. The appropriate interface must be selected and proper mask fit is critical; however, this cannot always be done and leaks can occur. Leaks are a major problem of non-invasive ventilation resulting in dyssynchrony between patient and the ventilator. To combat this issue, the C2 incorporates Hamilton's innovative IntelliTrig technology to compensate for leaks and assure a perfect synchronization between the patient and the ventilator. Contact hamilton-medical.com.

GOING UP

B&B Medical Technologies has introduced two new medical grade Heliox regulators with DISS fittings. The compact and versatile Heliox 70/30 DISS and Heliox 80/20 DISS regulators help medical facilities reduce costs by eliminating the need for two separate regulators for low flow Heliox therapy and high pressure gas delivery devices. Designed for use in critical care, special procedure units and emergency departments, the B&B regulators are easy to set up with either 70/30 or 80/20 Heliox H cylinders. Calibrated for delivery of precise flow and MRI compatible, no conversion or calibration of flow is needed to determine accurate Heliox flow. Easy to set up on H cylinders, the permanent O-ring design eliminates the need for a washer and provides hand tight seal at the yoke connection. The Heliox 70/30 DISS and Heliox 80/20 DISS regulators combine a calibrated "click style" flowmeter with barbed nipple for flows up to 25 Lpm plus an additional 50 psi male air connector for ventilator and other high pressure applications. Each regulator has a built-in unique color coded tank pressure indicator with 0-3000 psi operating range. The CGA yoke connector has a special inlet filter and all-brass construction in the high-pressure zones. The regulators are single stage, piston type with backpressure compensation and internal relief valve. The Heliox 70/30 DISS Regulator and the Heliox 80/20 DISS Regulator provide a complete system for simultaneous and independent delivery of metered constant flow Heliox and regulated high pressure gas. Contact bandb-medical.com.

EMERGENCY

Darren Braude, MD, an airway expert and educator and co-director of the Airway911 program at the University of New Mexico, has recently released the second edition of Rapid Sequence Intubation and Rapid Sequence Airway, An Airway911 Guide. This remains the only book focused exclusively on RSI. All aspects of RSI are covered in an evidence-based fashion, with

chapters including: Basic Principles, Pharmacology, The Difficult and Missed Airway, The Multiple Attempts Algorithm, Pediatric Considerations, The 10 Ps, Legal Issues, Documentation, and Quality Assurance. The book is written in a unique, easy-to-read conversational style. The 192-page text is supplemented with over 100 color photos and illustrations, tables and case scenarios, as well as color-coding to highlight key points, pitfalls and evidence-based material. This is a great introduction to RSI for RT students and a great review of the latest thinking and evidence for the experienced practitioner. The book may be purchased on Amazon or at airway911.com for \$50.

CRITICAL

The GEM Premier 3500 critical care analyzer (BG, Electrolytes, Metabolites, Glu, Lac, and optional CO-Oximetry [GEM OPL portable CO-Oximeter] and coagulation modules [GEM PLC Plus portable coagulation analyzer]) builds on the testing simplicity, flexibility and reliability of the GEM Premier 3000, offering new capabilities in an enhanced system, adaptable to the needs—and volume of the hospital and lab. With its self-contained cartridge, intuitive touch-screen displays and automated quality control, basic operation can be learned in minutes. iQM automates quality control and continuously detects, corrects and documents to assure quality results and compliance, 24/7, regardless of operator or testing location. GEMweb software allows information management and real-time communication throughout the hospital. Contact ilww.com.

UNBROKEN CIRCUIT

CareFusion introduced the new AirLife Closed Suction System. Clinicians understand that disconnecting or “breaking” of the ventilator circuit can lead to lung de-recruitment and hypoxemia, and it creates possible opportunities for cross-contamination and the development of Ventilator-Associated Pneumonia. The AirLife Closed Suction System is a multi-purpose device made up of modular components. It features the Verso Airway Access Adapter and its revolutionary Pucker Valve technology that seals the patient’s airway from the access port. The Verso adapter is placed in-line when setting up the ventilator circuit, so you can perform closed suction catheter change-outs and various airway access procedures through a single port without ever disconnecting the circuit. The system performs the following procedures through a single adapter: closed suction, open suction, bronchoscopic procedures, mini-BAL procedures, installed drug delivery, etc. Adult and neonatal options provide a full suite of products with catheter sizes ranging from 5 french through 16 french and specialty catheters including tracheostomy-length, directional-tip and fluid/access catheters. Contact carefusion.com.

OREGONIAN

Respiratory Technology Corporation (dba Restech) announced that The Oregon Clinic of Portland has adopted the Restech Dx-pH Measurement System to detect acid reflux in the airway. The Restech DX-System is utilized by The Oregon Clinic, Gastrointestinal & Minimally Invasive Surgery Division’s (GMIS) Foregut Program for the diagnosis and treatment of all diseases of the upper digestive system. Restech’s Dx-System provides valuable information about patients’ pharyngeal acid exposure and its role in various comorbidities, helping physicians diagnose the cause of each patient’s symptoms more accurately, and treat the patient more effectively. The miniaturized pH sensor at the tip of the Dx-pH Probe measures pH in a non-liquid environment, such as the pharynx. By monitoring the pH levels

in the pharynx, the Dx-System enables physicians to confirm or deny the presence of laryngopharyngeal reflux, and evaluate it as a possible contributor to their patients’ symptoms. The probe’s miniaturized, patented sensor is housed in the tear-drop shaped tip at the distal end of a thin transnasal catheter. An LED blinks during placement, allowing the medical personnel to confirm the proper placement in the oropharynx. The small size and minimally invasive position of the Restech Dx-pH Probe allows patients to carry on normal, everyday activities including eating, talking and sleeping with more comfort than conventional esophageal pH probes. The measurements taken by the pH sensor are sent wirelessly to a recording device which the patient carries throughout the study period. Upon completion of the study (usually 24 hours), the patient returns to the physician’s office where the data is downloaded and presented graphically for analysis using Restech’s custom Dx-pH DataView software. Contact restech-corp.com.

PRODUCT REVIEW

Edi (Electrical Diaphragm Activity)—a new respiratory vital sign?

The ability to measure the electrical activity of the heart with an electrocardiogram (ECG) has been a standard of care for so long we take its importance for granted. Now, for the first time, the ability to measure the electrical activity of the diaphragm (Edi) is available for bedside use with MAQUET SERVO-i Ventilators. An Edi catheter, designed like a typical naso- or orogastric tube, incorporates 10 miniaturized sensors. The Edi catheter enables the clinician access to the neural respiratory impulse, while providing feeding capability. The Edi directly reflects the neural input from the brain to the diaphragm (Sinderby C, Beck J. Proportional assist ventilation and neurally adjusted ventilatory assist—better approaches to patient ventilator synchrony? *Clin Chest Med.* 2008;29[2]:329–342). Upon esophageal insertion the catheter relays electrical diaphragmatic signals to the SERVO-i ventilator where digital Edi values and waveform are displayed. With Edi monitoring capability, clinicians can confirm spontaneous breathing effort in all modes of ventilation. When Edi is used with NAVA mode (Neurally Adjusted Ventilatory Assist) the SERVO i can adapt ventilator output to the patient’s own respiratory drive for improved synchrony. NAVA is the latest mode available with the MAQUET SERVO-i ventilator that uses the Edi signal to synchronize breath delivery providing pressure assistance in proportion to the Edi (Sinderby C, Navalesi P, Beck J, et al. Neural control of mechanical ventilation. *Nat Med.* 1999;5:1433–1436). Contact (888) 627-8383, maquet-inc.com.

PRODUCT FEATURE

NEWS FROM VAPOTHERM

The Neonatal Intensive Care Unit (NICU) at Children’s Hospital of Wisconsin, Fox Valley Campus is part of a state-of-the-art unit that was rated number 5 in the nation by Parents magazine. More than 700 infants with a wide variety of health and respiratory problems are cared for by Children’s Hospital of Wisconsin each year. The NICU features private newborn bed spaces that are specially designed to care for the patient from admission to discharge, the ability to perform certain procedures at the patient’s bedside, rooms that allow parents to practice caring for their baby before it goes home and an in-unit pharmacy with staff that is specially trained in the unique needs of the NICU.

Daneen Klehn, RT NICU Specialist, joined the department about two and a half years ago but she says that Vapotherm had already made its impact on the NICU long before she became a part of the team. Daneen favors Vapotherm technology for her patients because there is less equipment on the face of the baby and it is less invasive than CPAP. She also adds that when a patient is 28 weeks or older, she weans it off the ventilator to High Flow Therapy (HFT) within a 24 hour period. She does this because she says she notices a difference right away when the babies are placed on HFT. "The babies seem more relaxed. It's as if they know the therapy will help them get better." The NICU currently has four to five Vapotherm 2000i's running on a daily basis. The department has trialed the Precision Flow and is eager to add more units to the floor... In 2008, Centers for Medicare and Medicaid (CMS) considered adding Ventilator-Associated Pneumonia (VAP) to their list of "Never Events." Due to a concerted effort by the Respiratory and Critical Care field, VAP is currently listed as an "often unavoidable" condition. While VAP has not yet become a "Never Event," the costs of a single case can exceed \$35,000. The financial impact if such costs are not reimbursed in the future would be significant. To further decrease occurrences of VAP, the American Association for Respiratory Care has established recommendations based on Evidence Based Clinical Practice Guidelines. The recommendations include: Ventilator circuits should not be changed routinely for infection control purposes; Even though evidence supports a lower VAP rate with passive humidification than with active humidification, other issues related to use of passive humidifiers preclude a recommendation; Passive humidifiers do not need to be changed daily; Use of closed suction catheters should not be considered part of a VAP prevention strategy. High Flow Therapy, and Vapotherm, can be a key tool in potentially reducing or avoiding more invasive (and costly) procedures by eliminating MV when possible and reducing total ventilation time. Coding for Reimbursement: As with all of Vapotherm's products, you will want to code through the HCPCS Coding System under E0550 for "Heated Humidification." The average monthly reimbursement is about \$50. If the patient is a Medicare patient or Medicare is going to be a co-insurer you would have to bill them using the E0550 code. Vapotherm cannot make any recommendations on how to bill private insurers. In some instances, the Vapotherm 2000h has been billed for a specified payment via the E1399 "Miscellaneous Code." This is normally the process with non-Medicare neonatal and pediatric patients who are currently in the hospital but ready for discharge taking into account equipment, supplies and servicing. This approach is best supported by putting together an argument stating that paying "X" to the DME company a month is less expensive than paying "X+" a day to keep them in the hospital. This justification has also been a successful approach with some secondary or non-Medicare payers for adult patients. No matter which insurer or code you use, it is best to support your reimbursement request with documentation from the physician and/or hospital discharge planners to ensure maximum reimbursement. Contact clinicalsupport@vtherm.com.

SPOTLIGHT ON SPIROMETRY

COMPUTER-BASED

Medical Graphics Corporation, St Paul, MN, offers the Medgraphics CPFS/D USB computer based spirometer. From simple spirometry to complete bronchial provocation, the CPFS/D offers various testing capabilities and meets or exceeds

all current ATS/ERS recommendations for accuracy and performance. The patented Medgraphics preVent flow sensor provides accurate measurement and superior infection control. Its snap-in design allows for replacement between patients. Combined with BreezeSuite diagnostic software, the CPFS/D delivers quick testing, resulting in fast patient turnaround. Contact (800) 950-5597, medgraphics.com.

TAKING CARE

CareFusion is a leading designer and manufacturer of handheld, portable desktop and PC spirometers. CareFusion spirometers are essential to diagnosis and management of COPD, asthma and other respiratory diseases. Designed for ease of use, spirometry tests can be performed quickly and efficiently in all clinical and occupational health settings. Spirometry features include: full ATS/ERS 2005 compliance, PC connectivity, clear visual display of results, full graphical representation of blows, pre and post medication analysis and direct print capabilities. Contact carefusion.com.

LEGENDARY

nSpire Health's all-inclusive KoKo Legend portable spirometer exceeds ATS/ERS 2005 standards. KoKo Legend redefines accuracy through technology and simplicity with Legend's intuitive color touch screen, walking both patient and physician through standard testing procedures promoting superior patient test results. KoKo Legend utilizes a unique flexible orifice pneumotach which is extraordinarily precise at the low flow rates common in both pediatric and COPD patients. Choose built-in-printing or external office printing for 8½ x 11 reports. Easily transfer data into our KoKo PFT Spirometry software via a standard USB cable. For more information contact (800) 574-7374, nspirehealth.com.

PONY UP

COSMED is an Italian based company that manufactures spirometers that consist of the Pony FX and Microquark systems. The Pony FX is desktop-sized spirometer that has the following features: alphanumeric keyboard, a color LCD display, integrated printer, and PC software for data management and real time testing. The Pony FX includes the following tests: Spirometry (FVC, SVC, MVV, PRE-POST, Bronchial challenge). The Microquark is a PC-based spirometer with USB compatibility. The Microquark has the following features: Spirometry (FVC, SVC, MVV, PRE-POST, Bronchial challenge). Other features include pediatric Encouragement Software and a 3 year warranty. Contact cosmed.com.

SPOTLIGHT ON BLOOD GAS

ANALYZED

GEM Premier 4000 is the revolutionary analyzer (BG, Electrolytes, Metabolites, Glu, Lac, Hct, tHb, O₂Hb, COHb, HHb, MetHb, sO₂, BUN*, Creat*, Total Bili*, HCO₃*) with integrated CO-Oximetry that quickly provides consistent, accurate, lab-quality results throughout your hospital. Easy-to-use, touch-screen displays make it simple to select and customize parameters. Self-contained cartridges incorporate all components for patient testing and are maintenance-free. iQM automates quality control and continuously detects, corrects and documents to assure quality results and compliance, 24/7, regardless of operator or testing location. GEMweb Plus software enables remote access to any networked analyzer for

real-time status updates and supervision of remote locations [*-in development]. Contact ilww.com.

RAPID

Siemens Healthcare Diagnostics recently launched the RAPIDPoint 340 and 350 Blood Gas Analyzers for the low- to mid-volume critical care patient testing sites. These two low-maintenance models are small, easy-to-use cartridge-based systems, ideal for operators in a variety of critical care testing sites including intensive care units, operating or emergency rooms, and the clinical laboratory. The RAPIDPoint 340 Analyzer measures pH and blood gas (oxygen and carbon dioxide), while the RAPIDPoint 350 Analyzer also measures electrolytes, sodium, potassium, calcium or chloride, and hematocrit. Both models produce test results in just minutes, use a small sample size of 75 uL to 120 uL, and have the ability to interface with hospital and laboratory information systems. Contact siemens.com/diagnostics.

OPTIMAL

OPTI Medical Systems offers the OPTI R analyzer for the measurement of pH/blood gas, total hemoglobin, oxygen saturation, sodium, potassium and ionized calcium. The OPTI R coupled with the PrismPOC data management system makes obtaining and managing blood gas results easy and efficient. The system includes automated quality controls with continuous quality monitoring, advanced QC reports with statistical analysis, and web-based data management. The OPTI R has all of the performance and features of a normal bench top analyzer with the smallest footprint of any automated blood gas analyzer on the market. Contact (800) 490-6784, optimedical.com.

A BIG PLUS

Radiometer and Medical Automation Systems, Inc (MAS) have announced that they have begun a limited launch of a RALS-Plus module for Radiometer's ABL series blood gas analyzers. RALS-Plus is a widely used point-of-care (POC) data management system developed and marketed by MAS. Available in RALS-Plus, this module will enable users of Radiometer's ABL800 and ABL80 analyzers to automatically manage, report and electronically transfer patient blood gas data to the RALS-Plus database and the hospital's laboratory information system. Radiometer's ABL800 FLEX is equipped with FLEXQ, a module that automatically mixes and measures samples to ensure sample integrity for the best possible results. In addition, the ABL800 with FLEXQ automatically processes blood specimens, providing an unsurpassed level of automation in blood gas testing. The ABL80 is a portable, cartridge-based analyzer, offering fast turnaround, ease of use and no maintenance for POC applications. RALS-Plus is a leader in connectivity systems for POCT and provides users with total control of their program. At the click of an icon you can view all results that have been downloaded, display all results that have been flagged based on setup criteria, electronically manage all system operators, email weekly and monthly reports and so much more. In addition, MAS offers RALS-Web, which enables users to remotely connect to their RALS-Plus database and access key information from any device using a computer connected on the hospital network. Contact radiometeramerica.com.

UPTIME

The Roche Diagnostics cobas b 221 blood gas system helps clinicians maximize uptime while providing significant convenience and control with up to 40 days of onboard Auto

QC, up to 42 days of onboard stability of load and go reagents, and zero maintenance electrolytes. The configurable menu has options for blood gas (pO₂, pCO₂ and pH), electrolytes (Na⁺, K⁺, Cl⁻, Ca⁺, Hematocrit), metabolites (Glucose, Lactate, BUN), tHb/SO₂ and Co-oximetry (O₂Hb, HHb, COHb, MetHb, tHb, Bilirubin). With the only FDA 501(k) clearance for testing pleural fluid pH, as well as patient trending of data and automated acid-base mapping trending, the cobas b 221 system provides actionable information to healthcare providers and helps simplify regulatory compliance. The cobas b 221 blood gas system can be coupled with cobas bge link Instrument Manager software to enable monitoring and control of up to four decentralized systems from one location. cobas bge link enhances operational efficiency of all connected systems through screen sharing to provide immediate real-time performance status, maintenance updates and remote access for IT technical support 24/7. Contact roche.com.

OXIMETRY PRODUCT UPDATE

ACROSS THE SPECTRUM

Pulse oximetry has found its way into practically every area of clinical practice due to increasing advances over the past several years. New technologies have brought oximetry to a high level of efficiency and accuracy, enabling it to expand into patient diagnostics. The new BCI SPECTRO₂ Pulse Oximetry Portfolio from Smiths Medical is a welcome tool in clinical settings from acute care to EMS to home care. For more than 20 years, the BCI brand of pulse oximeters has been a recognized presence in the respiratory care marketplace. SPECTRO₂ Pulse Oximeters combine advanced technology and an array of accessories to help improve patient care and clinical efficiencies while providing the flexibility and convenience healthcare providers want. The portfolio's unique features provide reliability in a wide range of clinical settings. Features of the SPECTRO₂ Pulse Oximetry Portfolio include a Pulse amplitude Index (PI) bar-graph indicator to help clinicians choose a good test site, enabling confidence in the results; and an on-board cradle to store and protect the sensor, which helps reduce damage and unnecessary replacement costs. A new BCI spot-check finger sensor has a 20-inch cable to minimize the frustration of tangled cables. The SPECTRO₂ Pulse Oximetry Portfolio gives healthcare providers the flexibility to choose a pulse oximeter to meet their needs in virtually any clinical setting. The SPECTRO₂ 10 is a spot-checking oximeter that utilizes traditional oximetry technology and is intended for routine patient care assessment, management of episodic conditions, and wellness checks. The SPECTRO₂ 20 is a spot-checker that features BCI patented, digital Serial Autocorrelation technology designed to provide reliable performance in low perfusion or motion conditions. The SPECTRO₂ 20 is ideal for transport, triage and more unstable patients. The SPECTRO₂ 30 is intended for continuous monitoring of a patient's blood oxygen saturation and pulse rate. It is ideal for at-risk patients, overnight sleep screening, PACU and monitoring during analgesia administration. It features audible and visual alarms that include a highly visible beacon that lights during alarm states. In addition, the SPECTRO₂ 30's settings can be customized using its five-button key pad. Alarm limits, averaging, sensitivity, trend interval and operating modes can be set using the intuitive menu. The portfolio's optional accessories make it possible to customize a solution to suit each clinical environment's specific needs. Features include compatibility with all existing BCI sensors plus the new adult

and pediatric spot-check sensors featuring a shorter cable and convenient away-from-the-patient connection. A docking station easily converts the handheld device to a bedside monitor, and an attachable printer allows the user to print real-time and stored numerical and graphical trends. Protective gloves in four distinct colors, and various mounting options are also available. The oximeters can be powered by AA alkaline batteries, lithium ion rechargeable battery pack, or A/C power. Contact smiths-medical.com.

SLEEP PRODUCTS

IN MOTION

Ambulatory Monitoring, Inc (AMI), a pioneer of actigraphy in the 1980s, continues to offer its expanding line of Motionlogger Actigraphs to the sleep community. Adhering to highest standards—with a 95% sensitivity, 65% specificity and overall 88% agreement to polysomnography in mixed populations—AMI's Motionloggers provide the optimum adjunct tool to non-invasively and non-intrusively continuously monitor the sleep/wake patterns of subjects in their natural environment for long-term periods of time. Motionlogger models currently include features such as multi-mode data collection (for the most precise picture of the effects of nighttime sleep on daytime activity) and time-of-day display, (eliminating the need for subjects to wear a wristwatch). AMI's latest software for analysis of Motionlogger data is ActFAST. This program contains all of the features of AMI's well-known Action W clinical sleep estimation/database software together with performance estimates based on the highly validated FAST/SAFTE model, which also allows an expression of cognitive performance as an equivalent to blood/alcohol level. This innovation enables the clinician to clearly show a patient, in laymen's terms, how poor sleep negatively affects cognitive ability as well as how good sleep can enhance one's performance—driving home the important fact that fatigue and inadequate sleep are a deadly combination. As mentioned above and as documented by the American Academy of Sleep Medicine in practice parameter publications, actigraphy provides an adjunct tool for the study of sleep. Actigraphs are cost-effective, easy-to-use devices; and with the recent approval of a Category I CPT Code for actigraphy and impending CMS decision as to whether the monetary value for reimbursement of actigraphy will be left to the discretion of individual carriers or will become published national data in the fee schedule, it is foreseen that all sleep facilities will include actigraphy as part of their testing equipment in the near future. In addition to AMI's line of Motionlogger Actigraphs, the company also offers the PVT-192 Psychomotor Vigilance Task Monitor—a hand-held, self-contained system, which is the gold standard in reaction time measurement. Combined with easy-to-use React Software, the PVT has proven to be of extreme value when surrogate measures of performance and sleepiness are required, and it has been used extensively in the transportation and pharmaceutical industries as well as in the sleep community. Contact ambi.com.

IMPROVED FUNCTION

In two recent COPD studies sponsored by Dey LP, Pari's LC Plus nebulizer and Proneb compressors (Ultra and Ultra II) were used to show that nebulized formoterol fumarate (Perforomist, DEY LP, Mylan Inc) improves pulmonary function. Researchers used an open-label crossover design allowing them to catalog patient preferences regarding medication delivery. Patients felt greater treatment satisfaction and perceived better control of

their COPD with nebulized formoterol fumarate delivered by the LC Plus and Ultra II. The study compared nebulized formoterol fumarate to ipratropium/albuterol delivered via a metered dose inhaler. The study concluded that nebulized formoterol fumarate significantly improved pulmonary function and was more satisfactory to COPD patients than treatment with ipratropium/albuterol delivered via MDI. The researchers concluded that adding nebulized formoterol fumarate to maintenance tiotropium in COPD subjects provided significant improvements in pulmonary function, dyspnea, and rescue albuterol use over tiotropium alone. The incidence of adverse events was lower during treatment with formoterol/tiotropium compared to placebo/tiotropium.

FULL-FACED

Royal Philips Electronics announced the introduction of the FullLife full-face mask for the treatment of obstructive sleep apnea (OSA). This revolutionary mask covers both the nose and mouth, while being compact and offering a clear line of sight for patients. Representing a new generation of full-face masks, the FullLife is smaller and lighter, yet made of durable materials. The conventional forehead pad was eliminated to provide a clear line of sight. A newly designed, dual-textured cushion reduces leaks and creates a solid seal even with patient movement. The step-by-step numbered headgear system makes assembly and fitting easy. The FullLife mask is built on the same platform as the company's OptiLife mask, which was introduced in 2007. With a minimalist design and lightweight, durable materials, FullLife provides comfort and convenience for patients. Among its features, a clear line of sight benefits patients who feel claustrophobic, and an integrated exhalation port makes it exceptionally quiet for patients and their bed partners. With one faceplate for all three sizes (small, medium, and large), as well as FitPack and DuoPack fitting and supply replacement options, FullLife also is a good choice for clinicians and homecare providers. Contact philips.com.

SLEEP ROUNDTABLE

Braebon

Information provided by Richard A. Bonato, PhD, CEO and Co-Founder, Braebon.

What are the sleep products you offer?

Braebon has been selling quality sleep diagnostic products to leading facilities for over ten years. Our products include the 18-channel Type 2 MediPalm PSG recorder, the 12-channel Type 3 MediByte Snoring & Apnea recorder, and the 6-channel Type 3/4 MediByte Jr Snoring & Apnea screener.

What is the standard by which we should evaluate sleep testing diagnostics?

The latest portable monitoring guidelines published by the American Academy of Sleep Medicine on December 15, 2007 remain the most relevant and most recognized. Braebon's MediByte, for example, exceeds these new guidelines and uses the exact same technology in this Home Sleep Testing product as is recommended and used in leading sleep laboratories across the USA.

What are the advantages of home sleep diagnostics over traditional in-lab polysomnography?

If you ask ten people on the street if they'd rather sleep at home or in a sleep lab, they'll all tell you they'd rather sleep at home. So the first advantage is a more natural and comfortable sleeping environment, which we all know translates into a more realistic recording of the patient's breathing during sleep. Another advantage is lower per test cost than PSG. The MediByte has a per test cost in the neighborhood of \$8 and you can actually record two consecutive nights for a fraction of the cost of one night of PSG. This is advantageous for screening high probability OSA patients and expediting CPAP treatment. From a business perspective, home sleep diagnostics enable the clinician to expand beyond the traditional patient base and record those people who simply refuse to sleep in a laboratory. This advantage means you can now expand your target sleep apnea patient population which means more business for the sleep diagnostics provider.

How do you foresee the next several years in sleep related reimbursement? Is this changing product development trends?

During the next several years sleep related reimbursement will continue to evolve as Home Sleep Testing becomes increasingly commonplace. Some insurance companies are already encouraging HST as a method to reduce diagnostic costs, while at the same time diagnostic sleep providers are becoming more comfortable with using the technology to expand their diagnostic arm into the community. Product development will naturally follow this trend and will result in easier to use products with more sophisticated technology. Some people mistakenly believe HST is competitive to PSG rather than complementary, but nothing could be further from the truth. In other parts of the world HST is an extension of PSG services and they are not mutually exclusive.

What are the indications for the appropriateness of home sleep testing?

Obviously not all patients are candidates for HST. In general, those people with co-morbid health conditions should be more closely monitored with a routine PSG. Pediatric and geriatric patients may also require PSG rather than HST. Suitable HST candidates are the vast majority of middle-aged snorers and those suspected of OSA following clinician interviews accompanied by bed partners. Home Sleep Testing candidates must also be motivated and reasonably intelligent.

How are your products integrated for hybrid labs?

The hybrid lab has always been at the core of our vision for the future. Braebon's Pursuit Outcomes Business Software Solution actually interfaces with multiple PSG, HST, and CPAP products to vastly improve operational efficiencies and improve the bottom line. Our MediPalm is capable of both Type 1 attended PSG and Type 2 unattended HST. Our sleep sensor technology is identical when used in either sleep laboratories or in the home. We don't draw a line between lab or home. For us, the goal is to provide high quality products which accurately detect or record signals regardless of where the person is actually sleeping.

ResMed

Information provided by Drew Terry, Sr Director, Product Management, Sleep.

What are the sleep products you offer?

ResMed offers a full range of sleep therapy solutions including class-leading masks and flow generators. Over the last several years, ResMed has introduced a number of new technologies to ensure the best therapy is provided to the patient no matter what form of sleep-disordered breathing they suffer from. For example, three years ago ResMed introduced the first device specifically designed to treat all forms of central and complex sleep apnea, bringing relief to many patients who simply could not be adequately treated. ResMed has also introduced technologies that improve the treatment and comfort of patients suffering from obstructive sleep apnea. Easy-Breathe motor technology enables the quietest therapy on the market and extremely comfortable pressure delivery. ResMed also offers a series of fast, simple and easy-to-use portable monitoring devices, ApneaLink and ApneaLink Plus, for aiding in the screening and diagnosis of obstructive sleep apnea.

What is the standard by which we should evaluate sleep testing diagnostics?

Regulatory and reimbursement requirements should be considered when evaluating sleep testing diagnostics.

What are the advantages of home sleep diagnostics over traditional in-lab polysomnography?

Some of the advantages of home sleep diagnostics may be: the patient doesn't have to travel to a sleep lab or stay overnight; some patients may not be able to travel to a sleep lab due to disability or dependency limitations; in these tough economic times, to provide additional evidence to rule in or out the need for a more traditional in-lab polysomnography.

How do you foresee the next several years in sleep related reimbursement? Is this changing product development trends?

Payers are increasingly looking at ways to manage costs and evaluate compliance. As payers look for ways to measure compliance, they could consider adding a reimbursement component to continuous monitoring capabilities. An increased focus on the sleep market may contribute to the recognition of sleep-disordered breathing as a chronic condition that requires ongoing management. As the need for compliance information increases, manufacturers will see an increased demand for innovative solutions to capture and communicate the patient data as efficiently as possible.

What are the indications for the appropriateness of home sleep testing?

For qualified medical professionals, there could be several reasons where home sleep testing may offer options for screening or diagnosing obstructive sleep apnea. Once an assessment of the patient has been made, among the indications might be: difficulty in accessing a sleep lab, availability of schedule for in-lab services, reluctance of the patient to participate in an overnight study, hardship of being away from home overnight, or physical inability to go to a sleep lab.

How are your products integrated for hybrid labs?

ResMed products are used throughout the diagnosis and treatment process. For hybrid labs, ResMed products are used for monitoring and titration purposes during overnight studies and, once therapy is prescribed, used for treatment of OSA. ResMed products offer the ability to ensure patients get consistent therapy from titration to take-home device.

ActiGraph

What are the sleep products you offer?

ActiGraph offers an accelerometry based product (ActiSleep) that is utilized in determining over-all sleep efficiency.

What is the standard by which we should evaluate sleep testing diagnostics?

Relevant, cost effective and proven technology that adds clinical value to the patient and the over-all diagnostic and sleep proficiency process.

What are the advantages of home sleep diagnostics over traditional in-lab polysomnography?

a. Utilized in a patient's own bed; b. Less cumbersome ambulatory (wrist-worn) device; c. Screening tool prior to more extensive/expensive lab testing; d. Much less associated cost; e. Post therapy efficacy verification.

How do you see the next several years in sleep related reimbursement? Is this changing product development trends?

Obviously with the inception of the CPT Code for Actigraphy earlier this year, the future is promising for our science within the sleep world. However, and to take that a step further, we are in the very early stages of progression and we believe it will take some time before we see unilateral reimbursement levels under the process. As far as the trending and effects of reimbursement on product development, we just launched a new device that has significant enhancements over our previous model. Obviously, market traction will make a difference as to the speed in which further developments are released.

CleveMed

Information provided by Sarah Weimer, Director of Sleep Products.

What are the sleep products you offer?

CleveMed's current sleep product offerings include complete wireless PSG systems, such as the 14-channel Crystal Monitor 20-S and 20-B and the 22-channel Sapphire PSG. The SleepScout is a type III monitor for home sleep testing. All four systems include Crystal PSG software, a sophisticated software package for data acquisition, scoring and reporting. DreamPort and iPSG complement the PSG systems and expand the reach of your sleep business by allowing remotely attended sleep studies to be done from anywhere, using a bedside system controlled by sleep technologists.

What are the advantages of home sleep diagnostics over traditional in-lab polysomnography?

While not appropriate for all patients, HST can be a valuable tool in diagnosing patients. HST expands access to care for many patients by reducing cost and making the study more convenient.

These advantages may encourage patients who refuse in-lab testing to have a home test. I believe that HST will become a key component in following patients that are undergoing CPAP treatment. Periodically performing a home test with CPAP as a patient gains or loses weight or as a medical condition changes will allow for better titration of the CPAP over time. Checking the effectiveness of the CPAP and making adjustments as needed may increase patient compliance and lead to better patient outcomes.

How do you foresee the next several years in sleep related reimbursement? Is this changing product development trends?

Over the next several years in sleep and healthcare as a whole I believe there will be an emphasis on cost effectiveness of procedures. This may not lead to cuts in reimbursement but more restrictions on which patients may have an in lab study and how often a full PSG study may be performed. I believe that new products will be introduced that are designed to make HST easy to perform but to provide more diagnostic information with fewer sensors.

How are your products integrated for hybrid labs?

CleveMed used the same software, Crystal PSG, for all of our sleep products. This allows users to become accustomed to one software interface and easily switch between an in-lab study, a full PSG conducted at home and a Type III study.

Philips Home Healthcare Solutions

Information provided by Gretchen Jezerc, Director, US Marketing, Sleep Disordered Breathing

What are the sleep products you offer?

Philips Respironics offers a complete range of sleep therapy and diagnostic products and services, supporting sleep labs and homecare providers in treating patients across the care pathway—identification, diagnosis, titration, treatment, compliance management, and supply replacement. Respironics' Alice systems enable sleep labs to effectively diagnose patients with obstructive sleep apnea (OSA) and other sleep disorders, and are supported by industry-leading after-sales support and service. Our Sleep Therapy products are designed to meet the needs of providers and those of the patients they serve, working toward our common goal of comfortable patients who are adherent to their PAP therapy. The Flex Family of Pressure Relief Technologies, EncoreAnywhere data management system, and advanced Auto and BiPAP autoSV algorithms are designed to support DMEs and sleep clinicians with right-first-time therapies for patient success. We offer the Flex Promise Program to help providers move struggling CPAP patients to BiPAP therapy.

Finding the right mask for the patient is critical to therapy success. Philips Respironics offers a full range of nasal, pillows, and full-face masks, such as the new FullLife full-face mask. The revolutionary mask covers both the nose and mouth, while offering a clear line of sight for patients. The FullLife mask is built on the same platform as our successful OptiLife mask. And good-fitting gel technology is available in the ComfortGel mask. Philips Respironics offers a 30-day Satisfaction Promise Program to help get patients fitted with the mask that will work best for them.

What are the advantages of home sleep diagnostics over traditional in-lab polysomnography?

Labs can utilize home sleep testing to reach patients who otherwise would not receive sleep studies because they would not or could not come to a sleep lab. This is an advantage both for the sleep lab's business and for patient access. With the launch of the Alice PDx portable testing system, patients can easily read the Good Study Indicator on the unit's intuitive user interface whether they have had a successful study or not. This helps eliminate problems of repeat home tests due to insufficient data, saving time and money.

How do you foresee the next several years in sleep related reimbursement? Is this changing product development trends?

While we do not have a reimbursement crystal ball, reimbursement has certainly not trended upward in recent years, including the across-the-board 9.5% reduction earlier in 2009. Philips Respironics responded to changes in CMS PAP reimbursement guidelines by adding functionality to the EncoreAnywhere data management system to make it easier for physicians and homecare companies to collect, access, and manage the data they need to document patient compliance and achieve reimbursement. This functionality includes the Best 30 Days report and the Physician Follow-up report, among other features. EncoreAnywhere is a web-based system that enables sleep therapy caregivers to proactively gather, report and share information through a secure web portal. The system is intended to provide a lower cost, more timely and accurate method for monitoring patient acceptance to sleep therapy over manually-intensive legacy alternatives and to facilitate improved collaboration and intervention by caregivers to increase positive health outcomes. With a wired modem, prescriptions can be changed over the internet. The care team can identify struggling patients sooner and, if necessary, recommend a change in therapy, such as a different mask or a bi-level system. More efficient data management means that clinicians will have more time for patient education and follow up that is a key part of patient compliance. Our goal is to help homecare providers and sleep medical professionals achieve the compliance goals they establish.

What are the indications for the appropriateness of home sleep testing?

The decision on when and whether to use home sleep testing resides with the clinician.

How are your products integrated for hybrid labs?

Philips Respironics products help full-service sleep labs provide excellent care to their patients. Our Alice PDx portable sleep testing system integrates with our Sleepware software system and with our PAP devices. One patient data management system, EncoreAnywhere, can be used across the homecare provider and sleep lab, regardless of the data capture technology used—from phone-in compliance to SmartCards to modem.

Embla

What are the sleep products you offer?

Embla offers a complete range of sleep diagnostic products from home sleep testing, to full PSG. As a company we focus exclusively on sleep diagnostics, allowing us to find more innovative ways to make the diagnosis of sleep disorders more

efficient for our customers. An example of such innovation is our Cardio Pulmonary Coupling (CPC) module, a simple but powerful tool that can phenotype sleep disordered breathing from obstructive to complex sleep apnea. Sleep professionals can quickly establish and validate a patient's sleep quality by looking at a picture of sleep, and therefore determine the best treatment path to recommend. This Picture of Sleep is a powerful addition to the PSG or PG report, giving referring doctors an instant graphic representation of their patients sleep health. Our Enterprise Sleep Lab Management software is another time and money saving offering, which eliminates paper, optimizes workflow, increases occupancy rates, and decreases costly errors by eliminating multi point data entry. Enterprise also has endless report possibilities and is compatible with any PSG system. It is perfect for both freestanding or hospital labs and fully HL7 compatible. Over and above our reliable PSG software, RemLogic and line of amplifiers, Embla manufactures the most widely accepted portable sleep device in the industry, the Embletta, which boasts over half a million studies worldwide. We also consider our technical support service as one of our most valuable offerings. Embla support staff is ready to take calls 24/7.

What is the standard by which we should evaluate sleep testing diagnostics?

There is a wide spectrum of sleep disorders, and the severity of each will vary with every patient. This is true for obstructive sleep apnea, and while the standard of evaluating OSA should be done with sleep systems that allow labs to comply with AASM scoring criteria, and guidelines for unattended studies, today's standards should continue to be challenged in order to improve the accuracy of the diagnosis and efficiency of the testing process.

What are the advantages of home sleep diagnostics over traditional in-lab polysomnography?

Home Sleep Testing (HST) offers many advantages. Many labs with a patient backlog have turned to HST for patients who meet the criteria for an in-home study. Several of our PSG customers have found that a diagnostic HST followed by an in-lab titration study is a good model. This allows the patient to be diagnosed with apnea at home and allows the lab to focus its resources on the more complex titration phase of diagnosis. From the patient's perspective, it is much easier to be convinced that a full sleep test is necessary when they see their own results from a HST. HST also allows sleep professionals to widen the net in order to identify Sleep Disordered Breathing among a larger population.

How do you foresee the next several years in sleep related reimbursement?

There will remain a fine balance between cutting costs without sacrificing patient care. The fact that home sleep testing is being analyzed so carefully for the first time is an indication that the current model of reimbursement is being scrutinized and new, less traditional means of diagnosing sleep disorders are being considered.

Is this changing product development trends?

Product development is primarily a result of market trends, therefore the trend we are seeing of "less is more" will no doubt have an impact on the products being developed in the sleep diagnostic industry. Industry acceptance of new regulations and reimbursement models will be critical to the type of products being introduced to the market.

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Getting Involved

Donating Time and Professional Skills: Unique Volunteer Opportunities for Respiratory Therapists

Aimee D. Staggenborg, MA, BA, RRT

Volunteer Opportunities for RTs

Respiratory therapists have frequent opportunities to volunteer clinical services in what can be very unique and fulfilling ways. Getting involved in an organization that needs the skills of the RT presents a rewarding way to give back and promote ongoing community and global improvement. It takes a special individual to choose to donate one's personal time and professional services. The decision involves time away from family, friends, work and sometimes even using one's personal money to be part of a volunteer effort. Consider all the possible variables and obligations that are part of any volunteer opportunity before committing or signing on the dotted line.

Humanitarian Efforts

Humanitarian efforts, either medical or non medical, can be a richly rewarding volunteer assignment. There are many organizations (Globe Aware, Global Crossroads, among others) and local churches that provide medical care, basic human services, conduct field studies, provide infrastructure support, and ongoing sustainability logistics in local communities, around the country and around the world. Aid is provided in cases where human survival is threatened by violence, neglect, or disaster. Local and civil unrest may cause armed conflict and war, providing an immediate need for intervention and provision of aid. Other conditions that warrant assistance may stem from epidemics, malnutrition, exclusion from proper healthcare, and natural disasters. The role of the RT may be in a clinical or support role. There are many organizations that offer assignments in foreign countries. Keep in mind that many of these require a (tax-deductible) fee to be paid before placement will occur. This fee can range anywhere from \$200 or more, depending on the length and destination. These fees often do not include airfare, expenses, vaccinations, or emergency travel insurance and may require usage of PTO or vacation time to be excused from work in order to be involved.

Medical Missions Trips

Medical mission trips are similar to humanitarian efforts. On these trips, the RT may find him or herself included as part of a medical or surgical team on a specific mission to provide a particular medical or surgical service (Doctors without Borders,

International Children's Heart Foundation, among others) in an underdeveloped country. Children born with congenital heart disease may be surgically treated for a fraction of the cost with donated medical services from heart surgeons, nurses, respiratory therapists and other healthcare professionals. RTs are part of the medical or surgical team providing case management; treatment and training for pulmonary and respiratory disorders; care of the surgical patient during, and post-op; management and weaning the ventilator during open heart surgeries; equipment setup and troubleshooting, or clinical assessments with limited resources. Many organizations that provide these types of surgical teams usually either pay the volunteer a stipend, or cover the transportation, lodging, and some expenses. This type of assignment is generally shorter, lasting from just a few weeks to a few months.

Medical Air Transport

Medical air transport, unlike Med-Evac or air ambulance services, can be a volunteer position requiring donation of services by pilots, medical professionals, and other administrative workers. Medical Transport services, from groups such as Wings of Hope, offer services to those in need of transportation to a specialty doctor's visits, and clinics. They also provide transportation for patients returning home after recovery from a catastrophic injury or illness and unable to pay for private air transportation. The role for the RT in this position is to administer and manage in-flight oxygen when needed. The RT also provides assessment of oxygen saturations during flights and makes necessary recommendations for changes in altitude for the fixed wing aircraft. They may also suction the patient's tracheal or oral airway in flight as needed, or provide for overall patient in-flight care and comfort. The patient population is atypical and may have varying medical acuity levels. This type of opportunity generally only requires donation of one's time. Assignments are generally from six hours for a short round trip to two days for a longer transport trip. These non-profit organizations generally cover lodging and food expenses while on a mission.

Pulmonary Travel Escort

There is an underserved population of patients living with COPD and who must use oxygen 24/7, or patients who are ventilator dependent. Many of these people are "living" within

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their medical limitations. These patients may want to travel away from their homes by car, plane, train, or any other mode of transportation. Others may have the desire to take a vacation cruise. However, their limitations can present many logistic challenges while traveling. Acting as a volunteer travel escort can open up new horizons for these patients to travel, have fun, and experience new places. A pulmonary cruise is an interesting opportunity (Sea Puffers Pulmonary Cruises, for example) to provide respiratory therapist escorts on cruises. This can put a COPD patient at ease while on a cruise vacation. Pulmonary cruise volunteers provide initial patient assessment for medical needs during the trip, and they make arrangement for needed medical equipment and supplies for the trip. They also provide supplemental oxygen, O₂ saturation spot checks, or present onboard or in-port educational workshops on how to live and thrive despite having pulmonary disease. Those patients traveling with ventilators might want to explore and have fun while traveling. Often, patients traveling with ventilators are limited to car travel, but an RT can provide in-flight expertise, management of the ventilator and patient needs, and routine respiratory care while in-flight. The availability of air travel expands opportunities for the vent dependent and semi-dependent patient to new destinations and experiences. This type of opportunity may be available on a case by case basis and usually arranged by tour operators and travel agencies. Check with travel organizations in the local area to inquire about these types of positions.

Community Action

Community action organizations such as the American Red Cross provide emergency services at the local, state, national and international levels. This organization provides individual responses to single disasters, like family house fires, to larger disasters like hurricanes or mass flooding. When in need, community action teams are there to provide the basic essentials to meet human needs. These organizations serve as a beacon when people have lost everything by providing food, shelter, clothing and emergency healthcare. The role of the RT is only limited to the amount of time one can volunteer. The RT perspective can be a positive thing to the efforts of a community action group. Check with the local chapter for more information on this opportunity.

Community Emergency Response Teams

Community Emergency Response Teams (CERTs) educate people about disaster preparedness for hazards that may impact the local area. CERT also trains people in basic disaster response skills, such as fire safety, light search and rescue, team organization, and disaster medical operations. These teams are organized in local communities and often are the first line of disaster relief before medical personnel are able to respond. As a respiratory therapist volunteering for your local CERT, you have an excellent chance to be in the crucial first round of disaster aid to your neighbors and friends. Check with your local chapter organized by Citizen's Corp for more information on this volunteer opportunity.

Provide Asthma Education

Community outreach on asthma education is another way for RTs to be involved by providing asthma education through the A is for Asthma and Open Airways Programs. These programs focus on educating day care and school age children and their families about prevention, control and treatment of asthma. These programs are a joint venture between the American Lung

Association and the EPA as a way to decrease the number of fatalities and hospitalizations associated with untreated or undertreated asthma. RTs that hold the AE-C credential can provide asthma education and serve as a resource for questions and support. Check with your local school district or the American Lung association for more information on this type of opportunity.

Other types of volunteer opportunities

Respiratory therapists can use their professional skills over and above but not limited to the workplace. An RT could coordinate pulmonary disease support groups, like The Better Breathers Club, or AWAKE Meetings. These are opportunities to provide workshops, seminars, discussions for the treatment of COPD and sleep disorders. An RT may choose to volunteer to provide community outreach CPR and BLS classes for certifications through organizations, such as the American Red Cross or the American Heart Association. Special respiratory camps are always in need of specially trained staff to provide support for campers. Special respiratory camps are run by local chapters of the YMCA and other non-profit organizations. If interested in any of the opportunities or ones like it, check out the resource list below.

Whatever amount of time can be donated is always needed and RTs have special skills to enhance the experience. So get out there and donate time and RT medical and clinical expertise. Volunteering is rewarding, personally fulfilling, and needed to improve our global connection.

Resources

- 1 Doctors Without Borders www.doctorswithoutborders.org
- 2 International Children's Heart Foundation www.babyheart.org
- 3 Wings of Hope www.wings-of-hope.org
- 4 American Red Cross www.redcross.org
- 5 American Lung Association; Better Breathers Club and A.W.A.K.E <http://www.lungusa.org>
- 6 Sea Puffers Cruises www.seapuffers.com
- 7 American Heart Association www.americanheart.org
- 8 Federal Emergency Management Agency www.fema.org
- 9 Community Emergency Response Teams <http://www.citizencorps.gov/cert>
- 10 Young Men's Christian Association-Y.M.C.A. www.ymca.net
- 11 Globe Aware-Adventures in Service www.globeaware.org
- 12 Global Crossroad-Volunteer Abroad www.globalcrossroad.org

Cervical Spinal Cord Injury: The Role of High Frequency Chest Compression Therapy in the Management of Respiratory Complications

Jane Braverman, PhD; K. James Ehlen, MD

Spinal cord injuries (SCI) are catastrophic events that create significant burdens for victims, families, healthcare providers and taxpayers alike.¹⁻⁴ The financial costs of SCI are rapidly becoming unsustainable. In SCI care, as well as in other high-cost chronic conditions, only targeted, well executed “practice improvement” strategies are likely to powerfully alter the trajectory of skyrocketing costs.⁵⁻¹⁷ Critical reassessment of SCI management across the care continuum is vital to identify preventable complications and to implement effective interventions.^{5,6,16-20}

Respiratory complications—especially in patients with high-level cervical spinal injuries (CSI)—now rank as the leading cause of post-injury illness, rehospitalization and death.^{1-4,5-10,16-17} Altered respiratory mechanics, weakened pulmonary defenses and impaired secretion clearance are major contributory factors.^{5,17,24-29} Aggressive, targeted techniques to mobilize and clear retained bronchial secretions may prevent many of the episodes of pneumonia and respiratory failure that disproportionately deplete healthcare resources.^{5,16-22} The judicious addition of high frequency chest compression (HFCC) therapy to SCI respiratory care protocols has the potential to have a major impact upon achievement of this critical outcome.

The Status Quo

Since the 1970s, the incidence of spinal cord injury (SCI) has remained fairly static at 12,000 per year.^{1,3} However, its prevalence has changed dramatically; currently, an estimated quarter of a million Americans are SCI survivors. Advances in the emergency treatment of patients who just a few decades ago would have died within a day of their injury, as well as progress in long-term care, have led to increased survival and longer life expectancies.⁶ Improved pharmaceuticals and therapeutic medical devices account, in part, for better management of complex multi-system complications.^{11,31} Mechanical ventilators sustain life for about 7% of SCI survivors.²⁹

Degree of disability among SCI survivors varies greatly. Individuals who lose all or most function in all four limbs (tetraplegia/quadruplegia) have sustained injuries to one of the eight cervical segments of the spinal cord (C1-C8). Those with lower body (paraplegia) functional impairment have injured thoracic, lumbar or sacral regions of the spinal cord. At hospital discharge, the most frequent neurologic classifications, respectively, are: incomplete tetraplegia (30.1%); complete

paraplegia (25.6%); complete tetraplegia (20.4%); and incomplete paraplegia (20.4%).¹ Complete neurologic recovery at discharge occurs in fewer than 1% of patients.

Mortality rates are highest during the first year after injury. Thereafter, risk for death is proportional to the age at the time of the trauma and the severity of the injury. A twenty-year old with low tetraplegia (C5-C8) may anticipate an additional 41 years of life; with high tetraplegia (C1-C4), expected survival is 37 years.¹ Post-injury survival is sharply lower in patients who are ventilator-dependent, only 18 years.¹ Older individuals, especially those who are ventilator dependent, do less well.²⁹

Costs

SCI is now the second most costly condition treated in US hospitals, exceeded only by neonatal intensive care cases.^{6,12} Annual direct costs in the US exceed \$10 billion.^{8,30} Care expenditures are proportional to the neurologic level and extent of the injury. Although precise data are lacking, the National Spinal Cord Injury (NSCI) database provides figures annually extrapolated from information contributed by twenty-six Model SCI Care Systems. Estimates for 2008 rank average annual expenses and lifetime costs by severity of injury:¹

- High tetraplegia (C1-4) costs for the first year exceed \$800,000 and are about \$143,000 for each subsequent year.
- Low tetraplegia (C5-8) initial costs are estimated at \$517,000 and at \$59,000 for each additional year.
- Lifetime costs for high tetraplegia are about \$3,160,000 for a 25 year-old and \$1,860,000 for a 50 year old; for low tetraplegia, costs are placed at \$1,787,000 and \$1,132,000 respectively.

Figures do not include indirect costs such as lost earnings and/or productivity and non-professional caregiver expenses.^{1,10}

Long-term medical complications

In post-acute SCI, secondary medical complications are both inevitable and persistent. Although heart, kidney and digestive function are usually preserved, those systems are especially predisposed to complications arising from injury-related nerve damage. A broad variety of cardiovascular, respiratory, neurologic, renal, digestive, metabolic, musculoskeletal and dermatologic sequelae are well described in the literature.^{5,16-19,28,31} Three classes of complications, respiratory events, urologic problems and pressure ulcers, respectively, account overwhelmingly for the highest rates of healthcare utilization and rehospitalization.

This article was provided by Respiretech.

Respiratory complications

Respiratory complications (RC), especially pneumonias, are the leading, most rapidly increasing cause of outpatient visits, rehospitalization and, ultimately, death among SCI survivors.^{5-7,13,16,31} Although CSI patients are at highest risk, all groups are affected regardless of age or length of time post-injury. Post injury, about 50% of recurring costs are for respiratory-related in-patient care.⁸

Incidence and costs

Although database figures corroborate the disproportionate impact of RCs on morbidity and care costs, published studies shedding light on contributory causes are sparse. Most focus chiefly on epidemiological aspects of the problem.^{7-8,11-13,20,35} Clinical trials are few and limited.^{6,21,37,38}

- French, et al studied 675 SCI veterans for the year 2005 and found that hospitalization costs for a subset—tetraplegics with respiratory complications—approximated the total outpatient charges for the entire sample.⁸
- Smith, et al reported on data compiled from more than 8,700 respiratory-related outpatient visits by a population of over 13,000 SCI-injured veterans. Nearly all cases involved pneumonia. Annual utilization averaged 29-35/1000 veterans.²⁰
- Dryden, et al, in a smaller population-based study from Alberta, Canada reported a similar annual pneumonia incidence of 46/1000 patients.⁷
- In the largest and most comprehensive study to date, Winslow, et al, reviewed all cases of acute cervical spinal injury (CSI) treated at the Midwest Regional Spinal Cord Injury Care System for a 5-year period between 1993-1997. The objective was to determine the importance of RCs during the initial acute-care hospitalization as determinants of length of stay (LOS) and total hospital costs.⁶ Data showed that 1) LOS and hospital costs increase in direct proportion to the number of RCs occurring during that hospitalization and; 2) RCs that are considered secondary complications of cervical spinal injury (CSI) are as important as level of injury in prediction of LOS and hospital costs. Mean LOS and hospital costs increased in direct proportion to the number of RCs experienced. Four variables explained nearly 60% of the variance in both LOS and hospital costs: 1) use of mechanical ventilation; 2) occurrence of pneumonia; 3) need for surgery and; 4) use of tracheostomy. Each of these variables, when considered independently, are better predictors of hospital costs than level of injury. Winslow's results concur with earlier work investigating the same parameters.³⁶⁻³⁸

Without additional studies, actionable information is lacking concerning the etiological variables of adverse respiratory events or of the outcomes and costs associated with individual components of interventional care. For the present, policy-makers are compelled to combine relatively limited data with empirical and anecdotal evidence to identify weaknesses and to implement changes in SCI care guidelines and practices. What is clear, however, is the urgent need to direct major effort and resources towards identifying risk factors and taking steps to prevent and treat RC before clinic services and/or rehospitalization becomes necessary.^{5,7,17,20}

Secretion Retention in SCI

"Spinal cord injury has a profound effect on the respiratory system and pulmonary function. Paralysis or impairment of the respiratory muscles and the inability to cough or breathe

*deeply preclude normal mucociliary clearance. Consequent secretion retention, together with decreased lung volumes and diminished pulmonary functions influence development of atelectasis, bronchorrhea, and pneumonia. Dependence upon permanent or intermittent use of mechanical ventilation and associated aspiration of oropharyngeal secretions frequently leads to serial incidents of aspiration pneumonia."*²⁸

A consensus report

A major report entitled Treatment of Pulmonary Disease Following Cervical Spinal Cord Injury summarizes the findings of a Duke University Evidence-Based Practice Center research team charged by the federal government to investigate the causes and consequences of RC in SCI.¹⁷ Eight participating technical experts including pulmonologists, rehabilitation specialists, a respiratory therapist and a specialist in patient care concurred that bronchial secretion retention is a direct cause of pneumonia in high-level SCI (CSI).

*"All patients with Spinal Cord Injury [or quadriplegia from any cause] have an impaired ability to clear secretions. Retained secretions may plug bronchi and lead to atelectasis and eventually to pneumonia. Because patients with [quadriplegia] have decreased sensation of respiratory distress, the only signs and symptoms of impending respiratory failure from mucous plugging may be anxiety and increased respiratory rate. Failure to respond quickly to major mucous-plugging events may lead to respiratory arrest and death. Fever and purulent sputum may mark progression to pneumonia..."*¹⁷

Impaired ability to mobilize and evacuate bronchial secretions secondary to respiratory muscle weakness is the proximate cause of most RC in SCI.^{5,17,18,40} When expiratory muscle strength is insufficient to produce a peak cough flow of at least 160 L/minute, secretions do not advance effectively from the bronchi to the trachea.^{5,27,32} Obstructing secretions increase intrapulmonary shunt, diminish lung capacity, cause hypoxemia and increase work of breathing.⁴¹

Secretion overload in CSI is more than a simple consequence of respiratory muscle weakness and cough failure. Reduced sympathetic innervation to the lungs permits poorly regulated vagal parasympathetic activity, leading to bronchoconstriction and bronchial mucus hypersecretion.^{25,40} During the acute post-injury phase, mucus hypersecretion is common. Some patients may produce more than 1 liter of mucus daily.⁴⁰ A clearance burden of such proportions would tax even the most robust cough strength. Also as a consequence of CSI-related endocrine disruption, the physical quality of airway secretions may be remarkably thick and tenacious.⁴⁰ Many CSI patients develop diminished immune responses.^{5,33} In these circumstances, large burdens of stagnant, viscous secretions create an ideal environment for the growth and colonization of dangerous pathogens. Beyond adverse effects on pulmonary mechanics and the accumulation of abnormal flora, retained secretions encourage episodes of aspiration, atelectasis, pneumonia and respiratory failure.

Secretion Clearance Therapy; A vital treatment component

The Duke University team cited above concluded that many RCs in SCI are preventable or treatable. The need for routine assistive airway clearance therapy (ACT) is stated unambiguously:

“...treatments aimed at improving ventilation, cough, and secretion clearance may reduce the need for mechanical ventilation (MV)... Aggressive multimodal respiratory therapy interventions ... have been associated with improvements in atelectasis in a small case series... [and] also been associated with reduced mortality, atelectasis, the need for MV, and tracheostomy in a larger historical cohort.¹⁷

Two studies describe the effective use of aggressive pulmonary hygiene to prevent or reverse secretion retention and atelectasis in patients with CSI. Outcomes show a clear link between assisted secretion mobilization and fewer RCs, a decreased need for tracheostomy and MV support, and improved survival.

- McMichan, et al assessed the utility of 4X daily chest physiotherapy (CPT and assisted coughing in a prospective-retrospective study 22 consecutively admitted patients with acute traumatic quadriplegia (ATQ) compared to 22 similar patients receiving “usual care.” Outcome differences were dramatic: **mortality:** [aggressive care—0/22 (0%) vs usual care—9/22 (41%)]; **RCs:** [aggressive care—4 cases (18%) vs usual care -12 cases (55%)]; **mechanical ventilation:** [aggressive care -3/22 (14%) vs usual care—9/22 (41%)]; **tracheostomy:** [aggressive care—2/22 (9%) vs usual care—6/22 (27%)].³⁷
- Sugarman, et al, observed six quadriplegics (five with tracheostomies) admitted to an SCI service with marked left-sided atelectasis. All were treated with aggressive CPT and, if necessary, bronchoscopy. All six showed rapid resolution of atelectasis with chest x-rays returning to normal within 24 hours. Three patients relapsed with discontinuation of therapy.³⁹

Routine secretion management in CSI

Evidence supports the premise that aggressive mobilization of secretions in CSI may prevent or mitigate RC before patients become entrapped in a vicious cycle of recurrent pneumonia, hospital/ICU admissions and increased healthcare utilization. In current practice, airway clearance interventions are generally applied only after acute respiratory problems develop.⁵ For patients with CSI or those with other risk factors for aspiration or secretion retention, it makes sound clinical sense to institute a program of routine prophylactic ACT.¹⁷ In addition to CSI patients, routine ACT is also indicated for patients with lower level SCI who have developed evidence of bronchiectasis and/or have frequent respiratory-related healthcare needs.^{5,17-18} The challenge facing clinicians is to define and implement a “best practices” respiratory care strategy. Secretion mobilization must be a fundamental component of that strategy.

Approaches to secretion mobilization

A 2007 paper supported by the Department of Veteran’s Affairs and the Centers for Disease Control and Prevention presents a comprehensive review of acute respiratory infection in SCI together with a practical model for improved care practices.⁵ Secretion mobilization is a critical component of care recommendations. Physical/mechanical ACT modalities currently used in SCI medicine are enumerated:

- Manually assisted coughing (“quad coughing”)
- Mechanical insufflation-exsufflation
- Percussion (manual or with hand-held percussor)
- Postural drainage
- Suctioning

- Bronchoscopy
- Intrapulmonary percussive ventilation (IPPV)
- High-frequency chest compression (HFCC)

Each of these methods is shown to enhance secretion clearance. However,—with the sole exception of HFCC, all have intrinsic and extrinsic disadvantages that diminish their effectiveness in severely disabled patients. Because CSI/SCI patients have physical limitations and functional abnormalities, technique-related, patient-related, and institutional barriers prohibit their systematic implementation and limit their effectiveness. Technique-dependent therapies require skilled, labor-intensive support, are physically demanding of patients, increase risk for adverse events and consume costly resources. Moreover, again with the exception HFCC, none of these modalities is capable of reliably clearing secretions from the smallest, most peripheral airways.⁵⁰ It is in these regions that pathogens embedded in static mucus gain a foothold and refractory infections develop.

High-frequency chest compression (HFCC): The therapy of choice

HFCC is rapidly gaining acceptance as an important component of standard of care therapy for CSI patients. The method is safe and easy to use. It requires no active participation from the patient and only minimal staff effort. HFCC works by administering rapid but gentle compressive forces to the chest via an inflatable jacket.^{49,50} Oscillatory airflow is superimposed over a patient’s breathing cycle. Pressure pulses created within the jacket generate transient increases in airflow within the lung, resulting in high oscillatory volumes at the mouth and high peak expiratory flow rates simulating those seen in a cough. Basic research studies demonstrate several synergistic physiological effects that enhance mucus mobilization and clearance.⁴⁸⁻⁵⁴ Effects include alteration of the consistency of secretions, making them easier to clear. Oscillatory effects within the airways create an airflow bias that mobilizes secretions from the most peripheral lung regions toward progressively larger airways. Final clearance is accomplished by coughing, swallowing or suctioning. Patients without tracheostomies whose peak cough flow is below 160L/min will also require some form of cough assistance to complete clearance. HFCC is the only secretion clearance modality shown to mimic all the mucokinetic and mucolytic effects of healthy, well-functioning mucociliary clearance mechanisms.

HFCC: A safe, superior ACT modality for SCI/CSI patients

Clinical studies and more than twenty years of experience have established HFCC as a safe and effective therapy for long-term use in diverse patient populations.⁴⁹⁻⁵¹ A series of studies involving acutely ill, injured or post-surgical patients, as well as in medically complex individuals with chronic lung disease have shown comparable safety, tolerance and efficacy outcomes.^{51,58-62}

With appropriate care, HFCC is safe and suitable for stabilized patients with SCI/CSI including those who are dependent upon MV. The therapy has none of the barriers or limitations that compromise the safety and efficacy of alternative ACTs in patients with the physical and medical challenges that occur in SCI/CSI.^{43,62} HFCC is ideally suited to provide the aggressive, maximally effective secretion mobilization so urgently needed as a routine component of care in CSI.

- **HFCC is easy to use:** The therapy requires no special

positioning, is suitable for immobile, technology dependent patients, eliminates risk for postural-related hypoxemia and reduces risk for aspiration and gastroesophageal reflux (GER).^{43,49}

- **HFCC is well tolerated:** In all studies involving acute care, trauma or post-surgical patients, the overwhelming majority tolerated the therapy and, in most cases, preferred it over alternative interventions.^{51,58-62}
- **HFCC is technique-independent:** Consistent, effective therapy can be administered with minimal caregiver assistance. No active patient participation is required.^{43,49}
- **HFCC is clinically effective:** HFCC has been shown to clear secretions effectively and consistently, to preserve or improve lung function, to prevent or reduce atelectasis, to prevent or reduce episodes of infectious exacerbations and to reduce dependence upon antibiotic therapy and other medications.^{49,51}
- **HFCC is cost-effective:** The therapy is associated with fewer pulmonary exacerbations, reduced need for antibiotics, auxiliary care and laboratory services, and hospital and ICU admissions. Successful in-home treatments prevent or reduce exposure to nosocomial infection and other in-patient risks. Effective therapy may preclude need for MV. Effective treatment may facilitate ventilator weaning. Costs for daily professional services are minimized. A single device provides lifetime therapy.⁵¹

Conclusion

Although relatively uncommon, SCI/CSI are devastating events with immense personal, medical and economic consequences. Among survivors, chronic multi-system morbidities and attendant resource consumption present major challenges in management. More than half of all morbidity-related care costs are attributable to respiratory complications. In a large proportion of such cases, impaired ability to mobilize and evacuate bronchial secretions is a direct cause. As “best practices” approaches are developed to avoid respiratory complications in this population, clinical support for early and regular application of HFCC is growing. This therapeutic modality offers a clinically effective profile and is both comfortable and easy to apply. Evidence documenting the cost effectiveness for HFCC in the management of SCI/CSI patients is accruing; the significant reduction in burden of care is observable. As efforts to avoid or minimize preventable respiratory complications in these vulnerable individuals intensify, HFCC merits strong consideration for inclusion in the routine pulmonary care regimen.

References

- 1 Spinal Cord Injury Information Network: <http://www.spinalcord.uab.edu/show.asp?durki=119513>
- 2 VA Quality Enhancement Research Initiative (QUERI) for Spinal Cord Injury (SCI), United States Department of Veterans Affairs, http://www.sci.queri.research.med.va.gov/Model_SCI-QUERI.htm
- 3 National Spinal Cord Injury Statistical Center, Birmingham, Alabama: www.spinalcord.uab.edu
- 4 Paralyzed Veterans of America: <http://www.pva.org>
- 5 Burns SP, Acute Respiratory Infections in persons with spinal cord injury. *Phys Med Rehabil Clin N Am* 2007; 18: 203-216.
- 6 Winslow C, Bode RK, Felton D, et al. Impact of respiratory complications on length of stay and hospital costs in acute cervical spine injury. *Chest* 2002; 121: 1548-1534.
- 7 Dryden D, Saunders L, Rowe B, et al. Utilization of health services following spinal cord injury: a 6-year follow-up study. *Spinal Cord* 2004; 42 (90): 513-525.
- 8 French DD, Campbell RR, Sabharwal S, et al. Health care costs for patients with chronic spinal cord injury in the Veterans Health Administration. *J Spinal Cord Med* 2007; 30: 477-481.
- 9 Priebe MM, Chiodo AE, Scelza WM, et al. Spinal cord injury medicine: economic and societal issues in spinal cord injury. *Arch Phys Med Rehabil* 2007; 88 (Suppl 1): S84-S88.
- 10 Webster B, Giunti G, Young A, et al. Work-related tetraplegia: cause of injury and annual medical costs. *Spinal Cord* 2004; 42: 240-247.
- 11 Jackson A, Dijkers M, DiVivo M, et al, A demographic profile of new traumatic spinal cord injuries; change and stability over 30 years. *Arch Phys Med Rehabil* 2004; 2004; 85 (11) 1740-1748.
- 12 Elixhauser A, Steiner CA. Nationwide inpatient sample (NIS). Vol 1997. Rockville. MD. Agency for Health Care Policy and Research, 2000.
- 13 Jackson AB, Groomes TE. Incidence of respiratory complications following spinal cord injury. *Arch Phys Med Rehabil*. 1994 Mar; 75(3): 270-5.
- 14 Tator CH, Duncan EG, Edmunds VE et al. Complications and costs of managing acute spinal cord injury. *Paraplegia* 1993; 31 (11): 700-714.
- 15 Johnson RL, Brooks CA, Whiteneck GG. Cost of traumatic spinal cord injury in a population-based registry. *Spinal Cord* 1996; 34 (8): 470-480.
- 16 Cardenas DD, Hoffman JM, Kirshblum S, McKinley W. Etiology and incidence of rehospitalization after traumatic spinal cord injury: A multicenter analysis. *Arch Phys Med Rehabil* 2004; 85: 1757-1763.
- 17 Agency for Healthcare Research and Quality. Treatment of Pulmonary Disease Following Cervical Spinal Cord Injury. Rockville, MD. 2001. File Inventory, Evidence Report/Technology Assessment Number 27. AHRQ Publication No. 01-E014, September 2001. Under its Evidence-Based Practice Program, the Agency for Healthcare Research and Quality (AHRQ) develops scientific information for other agencies and organizations on which to base clinical guidelines, performance measures, and other quality improvement tools. Contractor institutions review all relevant scientific literature on the assigned clinical care topics and produce evidence reports and technology assessments, conduct research on methodologies and the effectiveness of their implementation, and participate in technical assistance activities.
- 18 Pillastrini P, Bordini S, Bazzocchi G, et al. Study of the effectiveness of bronchial clearance in subjects with upper spinal cord injuries: examination of a rehabilitation programme involving mechanical insufflation and exsufflation. *Spinal Cord* 2006; 44: 614-616.
- 19 Consortium for Spinal Cord Medicine. Respiratory management following spinal cord injury: a clinical practice guideline for healthcare professionals. *J Spinal Cord Med* 2005; 28: 259-293.
- 20 Smith BM, Evans CT, Kurichi JE, et al. Acute respiratory tract infection visits of veterans with spinal cord injuries and disorders: rates, trends, and risk factors. *J Spinal Cord Med*. 2007; 30: 355-361.
- 21 Burns S, Weaver F, Parada J, et al. Management of community-acquired pneumonia in persons with spinal cord injury. *Spinal Cord* 2004; 42 (80): 450-458.
- 22 Gauld LM. Review: Airway clearance in neuromuscular weakness. *Devel Med Child Neurol* 2009; 51:350-355.
- 23 DeVivo MJ, Krause JS, Lammertse DP. Recent trends in

- mortality and causes of death among persons with spinal cord injury. *Arch Phys Med Rehabil* 1999; 80 (11): 1411-1419.
- 24 Cotton BA, Pryor JP, Chinwalla I, et al. Respiratory complications and mortality risk associated with thoracic spine injury. *J Trauma* 2005; 59(6): 1400-1407; discussion 1407-1409.
 - 25 Schilero G, Grimm D, Bauman W, et al. Assessment of airway caliber and bronchodilator responsiveness in subjects with spinal cord injury. *Chest* 2005; 127 (1): 149-155.
 - 26 Lanig IS, Peterson WP. The respiratory system in spinal cord injury. *Phys Med Rehabil Clin N Am* 2000; 11 (1): 29-43.
 - 27 Jaeger RJ, Turba RM, Yarkony GM, Roth EJ. Cough in spinal cord injured patients: comparison of three methods to produce cough. *Arch Phys Med Rehabil*. 1993 Dec; 74(12): 1358-61.
 - 28 Slack, RS, Shucart W. Respiratory dysfunction associated with traumatic injury to the central nervous system. *Clin Chest Med* 1994; 15(4): 739-749].
 - 29 Shavelle RM, DeVivo MJ, Strauss DJ, et al. Long-term survival of persons ventilator dependent after spinal cord injury. *J Spinal Cord Med* 2006; 29: 511-519.
 - 30 Berkowitz M. Assessing the socioeconomic impact of improved treatment of head and spinal cord injuries. *J Emerg Med* 1993; 11 Suppl 1: 63-67.
 - 31 Chiodo AE, Scelza WM, Kirshblum SC, et al. Spinal cord injury medicine: long-term medical issues and health maintenance. *Arch Phys Med Rehabil* 2007; 88 (Suppl 1): S76-S83.
 - 32 Bach J, Saporito L. Criteria for extubation and tracheostomy removal for patients with ventilator failure. A different approach to weaning. *Chest* 1996; 110 (6): 1566-1571.
 - 33 Campagnolo D, Bartlett J, Keller S. Influence of neurological level on immune function following spinal cord injury: a review. *J Spinal Cord Med*. 2000; 23 (2): 121-128.
 - 34 Slonimski M, Aguilera EJ. *J Spinal Cord Med* 2001; 24 (4): 284-288.
 - 35 Ho CH, Wuermser LA, Preibe MM, et al. Spinal cord injury medicine: epidemiology and classification. *Arch Phys Rehabil* 2007; 88 (Suppl 10: S49-S54).
 - 36 Bellemare JF, et al, Complications of traumatic care: risk analysis of pneumonia in 10,001 adult trauma patients. *Am Surg*. 1996 Mar; 62(3):207-11.
 - 37 McMichan JC, et al, Pulmonary dysfunction following traumatic quadriplegia. *JAMA* 1980; 243 (6): 528-531.
 - 38 Sugarman B. Atelectasis in spinal cord injured people after initial medical stabilization. *J Am Paraplegia Soc* 1985 Jul; 8 (3): 47-50.
 - 39 Fishburne MJ, et al, Atelectasis and pneumonia in acute spinal cord injury. *Arch Phys Med Rehabil* 1990; 71 (3): 197-200.
 - 40 Bhaskar KR, Brown R, O'Sullivan DD, et al. Bronchial mucus hypersecretion in acute quadriplegic. Macromolecular yields and glycoconjugate composition. *Am Rev Respir Dis* 1991; 143 (3): 640-648.
 - 41 Jansen HM, Sachs AP, van Alphen. Predisposing conditions to bacterial infections in chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 1995; 151 (6): 2073-2080.
 - 42 Langenderfer B. Alternatives to percussion and postural drainage. *J Cardiopulm Rehabil* 1998; 18: 283-289.
 - 43 Braverman J. Maintaining healthy lungs: The role of airway clearance therapy. *Exceptional Parent* 2001; May: 10-15.
 - 44 Sutton PP. Chest physiotherapy: time for reappraisal. *Br J Dis Chest* 1988; 82: 127-137.
 - 45 Taylor CJ, Threlfall D. Postural drainage and gastro-oesophageal reflux in cystic fibrosis. *Lancet* 1997; 349 (9065): 1567-1568.
 - 46 McDonnell T, McNichols WT, FitzGerald MX. Hypoxia during chest physiotherapy in patients with cystic fibrosis. *Ir J Med Sci* 1986; 1986; 155: 345-348.
 - 47 Webber BA, Hodson ME. Effect of chest physiotherapy on oxygen saturation in patients with cystic fibrosis. *Thorax* 1990; 45: 77.
 - 48 Butcher SJ, Pasiorowski MP, Jones RL. Effects of changes in lung volume on oscillatory flow rate during high frequency chest wall oscillation. *Can Respir J* 2007; 14 (3): 153-158.
 - 49 Braverman J, Nozzarella M. High-frequency chest compression: advanced therapy for obstructive lung disease. *Resp Therp* 2007; 2 (2): 48-51.
 - 50 Dosman CF, Jones RL. High-frequency chest compression: a summary of the literature. *Can Respir J* 2005; 12(1): 37-41.
 - 51 Annotated Bibliography: High Frequency Chest Compression. www.respirtech.com
 - 52 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.
 - 53 Rubin E, Scantlen G, Chapman A, et al. Effect of chest wall oscillation on mucus clearance: comparison of two vibrators. *Pediatr Pulmonol* 1989; 6: 122-126.
 - 54 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.
 - 55 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
 - 56 Chang HK, Weber ME, King ME. Mucus transport by high-frequency nonsymmetrical oscillatory airflow. *J Appl Physiol* 1988; 65: 1203-1208.
 - 57 Gross D, Zidulka A, O'Brien C, et al. Peripheral mucociliary clearance with high frequency chest-wall compression. *J Appl Physiol* 1985; 58: 1157-1163.
 - 58 Allen JS, Garrity JM, Donohue DM. The utility of high-frequency chest wall oscillation therapy in the post-operative management of thoracic patients. *Respir Care* 2009; 54 (3): 340-343.
 - 59 Anderson CA, Palmer CA, Ney AL, et al. Evaluation of the safety of high-frequency chest wall oscillation (HFCWO) therapy in blunt thoracic trauma patients. *J Trauma Management and Outcomes* 2008; 2(8): 1-7.
 - 60 Brierley S, Adams C, Suelter J, Gooch T, Becker B. Safety and tolerance of high-frequency chest wall oscillation (HFCWO) in hospitalized critical care patients. *Respir Care* 2003; 48 (11): 1112.
 - 61 Ndukwu, IM, Shapiro S, Nam AJ, Schumm PL. Comparison of high-frequency chest wall oscillation (HFCWO) and manual chest physiotherapy (mCPT) in long-term acute care hospital (LTAC) ventilator-dependent patients. *Chest* 1999; 116 (4) Suppl: 311S.
 - 62 Braverman, J. High-frequency chest compression: a practical intervention for secretion retention in the ICU. *Resp Therpy* 2007/2008;2 (6): 26-29.

Administration of Iloprost with the Aeroneb Solo in a Patient with Primary Pulmonary Hypertension

Patricia A. Dailey, BS, RRT; Boyd Hehn, MD; Diane Desmaraisn, RRT

Introduction

Primary pulmonary hypertension is a devastating disease with an unknown etiology. Average duration of survival after diagnosis was approximately 2.8 years.¹ The advent of new treatment options such as inhaled prostacyclins have increased survival rates by as much as 10 years. Ventavis (iloprost) is an inhaled synthetic analogue of prostacyclin PGI₂ that produces potent pulmonary vasodilatation and inhibits platelet aggregation, among other benefits.^{2,3} The single patient use I-neb AAD System typically used to deliver iloprost is very costly at \$5,000 per system. Our desire was to determine the appropriate dose, assess medication tolerance, efficacy and patient compliance utilizing an efficient cost effective system. For this purpose we used Aerogen's Aeroneb Solo which utilizes vibrating mesh technology similar to the I-neb AAD System. Cost of the single patient use Aeroneb Solo is approximately \$42 and the multi-patient use controller unit is \$700, a significant difference.

Case Summary

The patient, a 73 year old woman diagnosed with primary pulmonary hypertension and underlying interstitial lung disease, was transferred to our institution solely for the purpose of prostanoid therapy under the direction of our medical director, a pulmonologist who specializes in pulmonary hypertension. We used the Aeroneb Solo with a one way valve and an expiratory filtration system in order to maximize medication delivery and minimize loss of medication into the surrounding environment (see figure 1).

The patient was initially trialed on a dose of 2.5 mcg of iloprost which she tolerated very well with no adverse effects associated with the medication. Subsequent doses were 5 mcg of iloprost given every 3 hours during waking hours for a total of 6 doses. Fill volume of the nebulizer was a total of 3 ml to achieve and administration time of 15 minutes. This required adding 2 ml of normal saline to the 1 ml solution of iloprost. Our reasoning behind increasing the treatment time was to provide a slower delivery time, minimizing the possibility of complications.

Discussion

Her respiratory status improved significantly with administration

The authors are with Baystate Medical Center. This article was provided by Aerogen.



Figure 1

of the inhaled iloprost via the Aeroneb Solo vibrating mesh nebulizer. Treatment produced a significant decrease in high-flow oxygen requirement via oxymizer from 9 lpm to 6 lpm with a corresponding increase in SpO₂ from 94% to 99%. This positive response demonstrates that Aeroneb Solo is a safe, efficient and cost effective delivery system for iloprost. Using the Aeroneb allowed us to treat the patient in a timely fashion and eliminate the need for unnecessary training and costs to the patient and the hospital. Previously, we would have had to wait for insurance approval, provide extensive training to the patient and staff, and acquire a very expensive nebulizer, all which would be a loss if the treatment was not tolerated or rejected by the patient.

References

- 1 Nauser TD, Sites, SW, Diagnosis and Treatment of Pulmonary Hypertension. *Am Family Phy* May 1, 2001.
- 2 Ventavis (iloprost) full prescribing information. Actelion Pharmaceuticals US, Inc. 2008.
- 3 Olschewski H, Simonneau G, Galie N et al, for the Aerosolized Iloprost Randomized Study Group. Inhaled iloprost for severe pulmonary hypertension. *N Engl J Med.* 2002;347:322-329.
- 4 Fink JB, Dunne P, O'Sullivan G. Can High Efficiency Aerosol Delivery Continue Post Extubation.

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Pulmonary Function Tests: Importance of Variability, Accuracy and Standardization. What is Significant?

Tarek Al Dammad, MD; Mohamed Saad, MD; Rodney J. Folz, MD, PhD

Introduction

All pulmonary function testing is subject to 1) technical variation related to instrument procedures, calibration, observer, subject, and their interactions, 2) biological variation, and 3) variation caused by dysfunction or disease. A knowledge and understanding of test variability can enhance the interpretation of PFT results through the separation of variability of interest (signal) from other sources of variation (noise) both within a subject and within a population. By quantifying the variability or reproducibility of a measurement for both normal subjects and patients with disease, the interpretation of the results is enhanced. In this article, we will review the guidelines and most recent literature to define importance of variability, accuracy and standardization in pulmonary function testing.

Definitions

A significant difference from normal is a measured value that would be expected in less than 5 percent of normal subjects.¹ Variability is the degree to which a measurement is variable. Repeatability is the variation in measurements taken by a single person or instrument on the same subject under identical conditions. A measurement is said to be repeatable if the variation measured is smaller than a predefined limit. If the variability of the results can be diminished and the measurement accuracy improved, then the range of normal values for populations can be narrowed and abnormalities more easily detected.

Spirometry

Spirometry is a physiological test, used to measure the rate at which the lung changes volume during forced breathing maneuvers. The most commonly performed tests are Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV₁), and Maximal Voluntary Ventilation (MVV). The FVC is one of the most important parameters measured. Through an FVC maneuver, both FEV₁ and the average forced expiratory flow rate over the middle 50% of the FVC (FEF₂₅₋₇₅) are measured and obtained.

The ATS/ERS document on standardization of spirometry defines the acceptable blow criteria (within maneuver criteria) as a satisfactory start of test and satisfactory end of test as shown in table 1.² It is important to try to achieve good repeatability (reproducibility) of FEV₁ and FVC within a spirometry test session because poor repeatability reduces confidence in the interpretation of bronchodilator or methacholine response (short-term) and long-term (month-to-month or year-to-year) changes in lung function.

Guidelines for the performance of spirometry have been based on published analyses of thousands of spirometry tests done by experienced technicians to ensure that the repeatability goals are practical. The current ATS criteria for satisfactory spirometry² are based on the 90th percentile values obtained during a large, population based survey, the Third National Health and Nutrition Examination Survey (NHANES).³ The ATS standard states that following three acceptable maneuvers, acceptable repeatability is achieved when the difference between the largest and the next largest FVC is ≤ 0.15 L and the difference between the largest and next largest FEV₁ is ≤ 0.15 L. For those with an FVC of ≤ 1.0 L, both these values are 0.10 L. If these criteria are not met in three maneuvers, additional trials should be attempted, up to, but usually no more than, eight maneuvers.

Machine variability is an additional factor contributing to the overall performance of the testing session. Current ATS recommendations specify a maximum device variability of 3%. It seems reasonable to decrease machine variability if possible. Devices should be calibrated according to ATS standards, and verified as often as necessary. The characteristics of flow-based measuring systems require that the calculated volumes be done at the various flows seen in patient populations, roughly from .2 liters/second, to 16 liters/second. If possible, the characteristics of the pneumotach, or flow sensor, should be displayed in testing situations, to assist the technologist in determining real-time accuracy.

Hankinson and Bang argued that FEV₁ and FVC repeatability goals should be stated as absolute differences (ml) and not as a percentage match (such as 5%).⁴ In 2004, Enright and colleagues studied 18,000 adult patients, and demonstrated that the amount of variance was always higher for repeatability expressed

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Table 1. Criteria for acceptable spiromgrams as adapted from Miller et al²

Within maneuver criteria	Between maneuver criteria
Individual spiromgrams are acceptable if: 1. Free from Artifacts Cough during the first second of exhalation, glottis closure, early termination, submaximal effort, leak, obstructed mouthpiece 2. Good Start Extrapolated volume < 5% of FVC or 0.15 L, whichever is greater 3. Satisfactory exhalation Duration of ≥ 6 sec (3 sec for children) or a plateau in the volume-time curve or if the subject cannot or should not continue to exhale	After 3 acceptable spiromgrams have been obtained, apply the following tests: 1. The two largest values of FVC must be within 0.15 L of each other. 2. The two largest values of FEV ₁ must be within 0.15 L of each other. If both of these criteria are met, the test session may be concluded. If not then continue testing until both criteria are met (total tests not to exceed 8 or the subject cannot or should not continue). Save, as minimum, the 3 satisfactory maneuvers.

Table 2. Cutoff for significance in PFTs, adapted from Pellegrino et al¹⁴

	FVC	FEV ₁	MEF25-75%	DLCO
Within a day				
Normal Subject	$\geq 5\%$	$\geq 5\%$	$\geq 13\%$	$>7\%$
COPD patients	$\geq 11\%$	$\geq 13\%$	$\geq 23\%$	
Week to week				
Normal subjects	$\geq 11\%$	$\geq 12\%$	$\geq 21\%$	>6 units
COPD patients	$\geq 20\%$	$\geq 20\%$	$\geq 30\%$	>4 units
Year to year	$\geq 15\%$	$\geq 15\%$		$> 10\%$

Table 3. Acceptable test criteria for DLCO as adapted from Macintyre et al²⁰

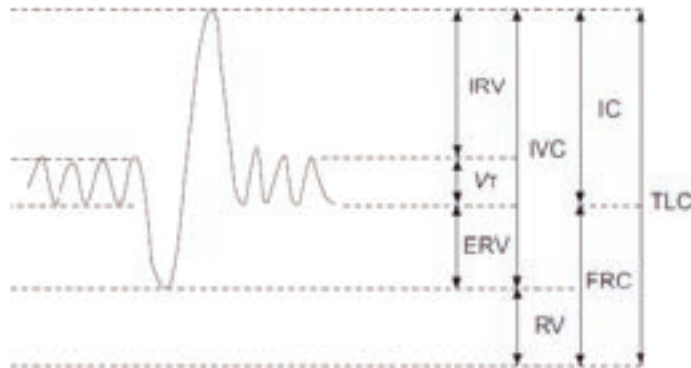
1. Use of proper quality-controlled equipment
2. Inspired volume of $> 85\%$ of largest vital capacity in <4 sec
3. A stable calculated breath hold for 10 ± 2 sec. There should be no evidence for leak, Valsalva or Mueller maneuvers.
4. Expiration in < 4 sec and sample collection time < 3 sec, with appropriate clearance of dead space volume and proper sampling / analysis of alveolar gas

as percentage, especially in females and short patients, but not as an absolute difference.⁵ They found that 9 of every 10 patients could match their highest FEV₁ within 120 ml, their FVC within 150 ml, and their PEF within 0.80 L/second. Most importantly they concluded that the ability of patients to meet or exceed spirometry repeatability goals does not depend on patient characteristics when testing is performed by experienced personnel. However, it does depend largely on the skill and perseverance of the technician.

What are the clinical predictors associated with variability in FEV₁? The Lung Health Study investigators found that the best independent predictors of the mean short-term (between visit) intra individual FEV₁ variability were factors indicating intrinsic airway reactivity of the participants:⁶ bronchodilator response, methacholine reactivity, and the presence of wheezing; as well as factors influenced by the quality of spirometry testing.

What is the short-term and long term variability of FEV₁ and FVC between test sessions in normal individuals and in patients with COPD? According to the ATS / ERS guidelines published in 2005,² Table 2 defines significant change and variability based on percentage changes.

Smaller previous studies have suggested that patients with COPD may have greater variability within and between spirometry test sessions than do individuals with normal lung function.²

Figure 1. Lung Volumes

Herpel and colleagues, in an interesting paper published in 2006, set out to determine short-term intra individual biologic and measurement variability in spirometry of patients with a wide range of stable chronic obstructive pulmonary disease.⁸ Using datasets from the National Emphysema Treatment Trial (NETT) and the Lung Health Study (LHS), they validated the use of absolute difference over percent difference in FEV₁ to assess intersession reproducibility and a clinically significant intersession change in FEV₁ in patients with COPD. Percent changes alone in FEV₁ should not be used to assess alterations in spirometry in patients with COPD. On the basis of their results, they suggested that a change of 225 ml absolute difference in FEV₁ could be used as a threshold to evaluate changes in lung function in patients with COPD. That is, a change of more than 225 ml has a high likelihood of representing a true change in lung function. They were less confident about what criterion would constitute a significant change in FVC. However, a 10% change, or 325 ml, was met by 90% of the participants.

In summary, to reduce variability in measurements and to enhance the detection of significant changes in spirometric values, the process starts with defining and validating equipment performance, maintaining regular quality control, followed by acceptable test procedure and maneuvers with defined acceptability and repeatability guided by a well qualified technician, reaching valid interpretation of test results based on available reference values in the setting of solid clinical assessment and knowledge of accepted changes in pulmonary function that reach statistical significance.² Furthermore, enhanced technology that allows us to reduce machine variability from 3% to 1% would be equivalent to reducing the variability measured by as high as 80 ml in a 4 L FVC maneuver.

Lung Volumes

The term lung volume usually refers to the volume of gas within the lungs, as measured by body plethysmography, gas dilution or washout.² Measurement of static lung volumes is essential. The most important volumes are the slow vital capacity (SVC), residual volume (RV) and total lung capacity (TLC). Figure 1 shows the classic description of the major lung volumes and lung capacities. The FRC (functional residual capacity) is defined as the lung volume at which the inward elastic recoil of the lung is balanced by the outward elastic forces of the relaxed chest wall. It is normally 40 to 50% of TLC. The determination of FRC is the key component in the measurement of lung volumes. A comprehensive listing of published reference equations for lung volumes was published by ATS/ERS and the ECCS, in 1995 and 1993 respectively.^{10,11}

Evaluation of an individual's change in lung function following

an intervention or over time is often more valuable clinically than a single comparison compared to an external reference (predicted) value. The variability of lung volume measurements has been reviewed by Hankinson et al.¹² The within subject biological variability for lung volumes, as with spirometry, may not be the same for all subjects. This seems particularly true for subjects with obstructive airway disease where functional residual capacity (FRC) and residual volume (RV) are increased. However, there does not appear to be a significant increase in variability of FRC in obstructive lung disease when measure by plethysmography (FRC_{pleth}).¹³

This lack of increased variability of lung volumes may, in part, be explained by the common practice of expressing the variability as a percentage. This is in contrast to FEV₁ and FVC in which reproducibility should be expressed in absolute terms rather than a percentage. While most studies have reported the coefficient of variation (CV), expressed as a percentage, it may be more appropriate to express test variability in absolute terms by calculating the coefficient of repeatability (CR) instead of the more popular coefficient of variation as recommended by the ATS/ERS.¹⁴ Although there have been several attempts at establishing limits for lung volume reproducibility, standardization is still lacking.

The European Respiratory Society statement concluded that the CV for FRC reproducibility using the single breath nitrogen technique is 8%.¹¹ For FRC_{pleth}, they concluded that a lower variability was appropriate or 5% for both healthy individuals and patients with airways obstruction. The Intermountain Thoracic Society concluded that with three tests, the CV for plethysmographic measurement of total lung capacity (TLC_{pleth}) should be within 5%. For helium dilution tests (two tests), a 5% reproducibility criterion was recommended when using an automated method and 8% with a manual method. The American College of Chest Physicians in 1986 recommended that 3 tests of FRC_{pleth} be reproduced to within 10%. One textbook of pulmonary medicine recommends that for multiple nitrogen washout tests, the FRC in normal subjects should agree within 200 to 400 mL in adults and 100 to 200 mL in children.¹⁵

In summary, lung volume variability and reproducibility is not as well defined in the literature as compared to spirometry. Equipment standardization and regular quality control, followed by acceptable test procedure and maneuvers guided by a well qualified technician all are needed to facilitate conducting large clinical studies to define variability of lung volumes in health and disease, as well as during short-term and long-term follow up.

Diffusion Capacity

Measurement of single-breath diffusing capacity of the lung (DLCO) is an integral component of the assessment of lung function in health and disease. The diffusing capacity of the lung for CO (DLCO) is defined as the total uptake of CO by the lung per unit of time per unit driving pressure (ml/min/mmHg). DLCO is mainly determined by membrane conductivity (DM) and the association of CO and Hgb. The DM reflects the diffusion properties of the alveolar capillary membrane, whereas the binding of CO and Hgb represents the product of the CO-Hgb chemical reaction rate (θ) and the volume of Hgb in alveolar capillary blood (Vc).

It is important to distinguish genuine changes in DLCO over time from natural variability. The process starts with an acceptable

test criteria as shown in Table 3.

Intersession variability in DLCO measurements exists as a consequence of biological and measurement variability.^{16,17} DLCO measurements show substantial variability between different pulmonary function test laboratories, in spite of attempts to standardize its testing. Wanger and Irvin have shown that healthy trained subjects had a substantial variation in measured DLCO when tested at 13 pulmonary function laboratories in a major metropolitan center.¹⁸ However, in a recent study by Wise RA and colleagues, the author showed that the standardized methodology employed in the study demonstrates the feasibility of collecting high-quality single-breath DLCO data in the setting of a multicenter clinical trial with reliability that is comparable to spirometry.¹⁹

Current American Thoracic Society/European Respiratory Society (ATS/ERS) guidelines state that a change of more than 10% in DLCO over 1 year should be considered clinically significant.²⁰ This value is derived from the work of Hathaway and colleagues, who reported on the intra individual variability in five DLCO measurements in eight healthy trained pulmonary function technicians over 1 year.²¹ Drummond and colleagues, in a recent paper addressing intersession variability in single breath diffusing capacity in diabetics without overt lung disease; have shown that the expected variability in DLCO measurements over time in stable individuals is substantial and depends on the method of testing used (highly standardized vs. routine testing methods) and their baseline DLCO.²² The authors concluded that using a more liberal threshold (20-25% rather than 10%) to define meaningful intersession change may reduce the misclassification of normal variation as abnormal change.

In summary, the DLCO has substantial variability that can be reduced by applying highly standardized methodology in different pulmonary function test laboratories and it appears that based on more recent literature, the ATS/ERS criteria of significance with respect to DLCO variability, may need to be revisited.

Conclusion

Following a systematic review of the literature on pulmonary function testing variability, it becomes clear that focusing on universal standardization guidelines, following rigorous testing techniques, and developing well qualified technicians are key elements to minimizing PFT noise and variability. Device accuracy is another variable that can be measured and quantified. It seems reasonable that the greater control the technician has, and the greater accuracy of the device, the better and more helpful the information obtained from the test will be. Determining what is a significant change in PFT will be better understood, and quantified, when we establish more precise reference equations that are reflective of normal populations, understand the natural history of PFTs in lung disease, and when we can minimize technician and machine-related variability.

References

- 1 Bland M. Repeatability and precision in measurement. An introduction to medical statistics: Oxford Medical Publications; 1987. p. 276-278.
- 2 Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, Crapo R, Enright P, van der Grinten CP, Gustafsson P, et al. Standardisation of spirometry. *Eur Respir J* 2005;26:319-338.

- 3 Hankinson JL, Odencrantz JR, Fedan KB. Spirometric reference values from a sample of the general U.S. Population. *Am J Respir Crit Care Med* 1999;159:179-187.
- 4 Hankinson JL, Bang KM. Acceptability and reproducibility criteria of the American Thoracic Society as observed in a sample of the general population. *Am Rev Respir Dis* 1991;143:516-521.
- 5 Enright PL, Beck KC, Sherrill DL. Repeatability of spirometry in 18,000 adult patients. *Am J Respir Crit Care Med* 2004;169:235-238.
- 6 Enright PL, Connett JE, Kanner RE, Johnson LR, Lee WW. Spirometry in the lung health study: II. Determinants of short-term intraindividual variability. *Am J Respir Crit Care Med* 1995;151:406-411.
- 7 Pennock BE, Rogers RM. An evaluation of tests used to measure bronchodilator drug responses. *Chest* 1978;73:988-989.
- 8 Herpel LB, Kanner RE, Lee SM, Fessler HE, Scirba FC, Connett JE, Wise RA. Variability of spirometry in chronic obstructive pulmonary disease: Results from two clinical trials. *Am J Respir Crit Care Med* 2006;173:1106-1113.
- 9 Wanger J, Clausen JL, Coates A, Pedersen OF, Brusasco V, Burgos F, Casaburi R, Crapo R, Enright P, van der Grinten CP, et al. Standardisation of the measurement of lung volumes. *Eur Respir J* 2005;26:511-522.
- 10 Stocks J, Quanjer PH. Reference values for residual volume, functional residual capacity and total lung capacity. *ATS workshop on lung volume measurements. Official statement of the European Respiratory Society. Eur Respir J* 1995;8:492-506.
- 11 Quanjer PH, Tammeling GJ, Cotes JE, Pedersen OF, Peslin R, Yernault JC. Lung volumes and forced ventilatory flows. Report working party standardization of lung function tests, European Community for steel and coal. Official statement of the European Respiratory Society. *Eur Respir J Suppl* 1993;16:5-40.
- 12 Hankinson JL, Stocks J, Peslin R. Reproducibility of lung volume measurements. *Eur Respir J* 1998;11:787-790.
- 13 Bohadana AB, Teculescu D, Peslin R, Jansen Da Silva JM, Pino J. Comparison of four methods for calculating the total lung capacity measured by body plethysmography. *Bull Eur Physiopathol Respir* 1980;16:769-776.
- 14 Pellegrino R, Viegi G, Brusasco V, Crapo RO, Burgos F, Casaburi R, Coates A, van der Grinten CP, Gustafsson P, Hankinson J, et al. Interpretative strategies for lung function tests. *Eur Respir J* 2005;26:948-968.
- 15 Clausen JL. Prediction of normal values. In: Clausen JL, editor. *Pulmonary function testing, guidelines and controversies*. New York: Academic Press; 1982.
- 16 Jensen RL, Teeter JG, England RD, Howell HM, White HJ, Pickering EH, Crapo RO. Sources of long-term variability in measurements of lung function: Implications for interpretation and clinical trial design. *Chest* 2007;132:396-402.
- 17 Jensen RL, Teeter JG, England RD, White HJ, Pickering EH, Crapo RO. Instrument accuracy and reproducibility in measurements of pulmonary function. *Chest* 2007;132:388-395.
- 18 Wanger J, Irvin C. Comparability of pulmonary function results from 13 laboratories in a metropolitan area. *Respir Care* 1991;36:1375-1382.
- 19 Wise RA, Teeter JG, Jensen RL, England RD, Schwartz PF, Giles DR, Ahrens RC, MacIntyre NR, Riese RJ, Crapo RO. Standardization of the single-breath diffusing capacity in a multicenter clinical trial. *Chest* 2007;132:1191-1197.
- 20 MacIntyre N, Crapo RO, Viegi G, Johnson DC, van der Grinten CP, Brusasco V, Burgos F, Casaburi R, Coates A, Enright P, et al. Standardisation of the single-breath determination of carbon monoxide uptake in the lung. *Eur Respir J* 2005;26:720-735.
- 21 Hathaway EH, Tashkin DP, Simmons MS. Intraindividual variability in serial measurements of dlco and alveolar volume over one year in eight healthy subjects using three independent measuring systems. *Am Rev Respir Dis* 1989;140:1818-1822.
- 22 Drummond MB, Schwartz PF, Duggan WT, Teeter JG, Riese RJ, Ahrens RC, Crapo RO, England RD, MacIntyre NR, Jensen RL, et al. Intersession variability in single-breath diffusing capacity in diabetics without overt lung disease. *Am J Respir Crit Care Med* 2008;178:225-232.

Diagnostic Accuracy of Spirometry in Primary Care

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Abstract

Background: To evaluate the sensitivity, specificity and predictive values of spirometry for the diagnosis of chronic obstructive pulmonary disease (COPD) and asthma in patients suspected of suffering from an obstructive airway disease (OAD) in primary care.

Methods: Cross sectional diagnostic study of 219 adult patients attending 10 general practices for the first time with complaints suspicious for OAD. All patients underwent spirometry and structured medical histories were documented. All patients received whole-body plethysmography (WBP) in a lung function laboratory. The reference standard was the Tiffeneau ratio (FEV1/VC) received by the spirometric maneuver during examination with WBP. In the event of inconclusive results, bronchial provocation was performed to determine bronchial hyperresponsiveness (BHR). Asthma was defined as a PC20 fall after inhaling methacholine concentration $\leq 16\text{mg/ml}$. Results: 90 (41.1%) patients suffered from asthma, 50 (22.8%) suffered from COPD, 79 (36.1%) had no OAD. The sensitivity for diagnosing airway obstruction in COPD was 92% (95%CI 80-97); specificity was 84% (95%CI 77-89). The positive predictive value (PPV) was 63% (95%CI 51-73); negative predictive value (NPV) was 97% (95%CI 93-99). The sensitivity for diagnosing airway obstruction in asthma was 29% (95%CI 21-39); specificity was 90% (95%CI 81-95). PPV was 77% (95%CI 60-88); NPV was 53% (95%CI 45-61).

Conclusions: COPD can be estimated with high diagnostic accuracy using spirometry. It is also possible to rule in asthma with spirometry. However, asthma can not be ruled out only

using spirometry. This diagnostic uncertainty leads to an overestimation of asthma presence. Patients with inconclusive spirometric results should be referred for nitric oxide (NO)—measurement and/or bronchial provocation if possible to guarantee accurate diagnosis.

Background

Asthma is a common chronic disease with a high prevalence of approx. 5% in industrialized nations. It is characterized by a chronic inflammation process which induces bronchial hyperresponsiveness and in most cases, reversible airway obstruction.¹ Another common pulmonary disease is chronic obstructive pulmonary disease (COPD) which shows irreversible airway obstruction, and which is mostly caused by inhaling tobacco smoke.² The prevalence of COPD is estimated to be around 10% and expected to be the fourth most important cause of death in 2020.³ Due to this high morbidity, general practitioners play a key role in detecting the disease as they see patients during the earlier stages of disease. Spirometric investigation is seen as a gold standard for diagnosing airway obstruction. Therefore, office spirometry is increasingly seen as a quality standard in general practice.^{4,5} The efficacy of spirometry in diagnosing COPD was demonstrated by a specialist team, which received referrals for performing spirometry and bronchodilator reversibility testing in patients suspected of having COPD.⁶ The DIDASCO Study revealed the difficulty of diagnosing COPD with screening questionnaires only and concluded that spirometry is essential for early diagnosis.⁷ These investigations focused on COPD only, which is marked by irreversible airway obstruction. The diagnostic value of spirometry for diagnosing asthma marked by reversible airway obstruction remains unclear. This is of importance, as asthma needs to be diagnosed by bronchial provocation testing when spirometry shows no airway obstruction.⁸ One diagnostic study in primary care used spirometry and bronchial provocation testing for identifying patients with asthma and COPD.⁹ However, this was only carried out in patients complaining of suffering from a cough; and spirometry was performed by a single specialist. Spirometry and bronchial provocation testing were also used in the DIMCA study.¹⁰ Indeed this was a screening study performed in a specialist center to detect patients in early stadiums of asthma or COPD. Due to the design of these asthma and COPD trials, there is no evidence of the diagnostic accuracy of spirometry

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Table 1: Characteristics of the study population. Values are number (proportion) or mean (SD); OAD = obstructive airway disease; COPD = Chronic obstructive airway disease (n=219)

	Overall n (%)	Asthma n (%)	COPD n (%)	No OAD n (%)
n	219 (100)	90 (100)	50 (100)	79 (100)
Female	127 (57.7)	55 (61.1)	26 (54.1)	46 (58.2)
Obesity	30 (13.7)	8 (8.9)	10 (20.0)	12 (15.2)
Age (mean in years [sd])	43.8 [15.6]	37.9 [14.4]	56.9 [11.5]	42.1 [14.4]
Do you sometimes suffer from shortness of breath? (yes)	135 (61.4)	55 (61.1)	39 (76.3)	41 (51.9)
Have you suffered from wheezing in your chest? (yes)	108 (49.1)	47 (52.2)	30 (63.2)	30 (38.0)
Do you often suffer from a cough? (yes)	126 (57.3)	39 (43.3)	32 (65.8)	55 (69.6)
Do you often suffer from expectoration? (yes)	74 (33.6)	22 (24.4)	20 (36.8)	32 (40.5)
Have you been woken up with a feeling of tightness in your chest? (yes)	49 (22.3)	27 (30.0)	9 (10.5)	13 (16.5)
Have you been woken up by an attack of shortness of breath? (yes)	48 (21.8)	24 (26.7)	10 (18.4)	14 (17.7)
Have you suffered an asthma attack? (yes)	14 (6.4)	11 (12.2)	2 (2.6)	1 (1.3)
Do you suffer from any nasal allergies? (yes)	92 (41.8)	44 (48.9)	14 (31.6)	34 (43.0)
Do you often suffer from a common cold? (yes)	73 (33.2)	18 (20.0)	18 (26.3)	37 (46.8)
Do you smoke or did you smoke? (yes)	118 (53.4)	35 (38.9)	43 (86.8)	39 (49.4)
How much do / did you smoke? (mean in pack year [SD])	11.6 [17.7]	6.6 [12.9]	28.8 [21.7]	6.4 [11.9]

Table 2: Performance of spirometry in general practice (n=216)

Interpretation of flow-volume curve	n (%)	Bronchodilation test	n (%)
Full adherence to ERS	86 (39.8)	Was not necessary	138 (36.1)
Adherence to ERS but only two flow-volume curves	69 (31.9)	Was necessary and performed	37 (17.1)
No adherence to ERS but first flow-volume curve perfect and showing no pathological signs	13 (6.0)	Was necessary but not performed	41 (19.0)
No adherence to ERS showing no obstruction	15 (6.9)		
No adherence to ERS indicating airway obstruction	33 (15.2)		

itself. Therefore, the true degree of the associated diagnostic uncertainty for patients with complaints suspected of having an airway obstruction remains unclear. The need for closing this gap of knowledge has been pointed out several times.^{11,12} The difficulty is that the pretest probability of a disease and its severity in primary care is lower when compared to a hospital setting, thus hampering the predictive values of diagnostic tests.^{13,14} Therefore, test results evaluated in hospital settings can not easily be transferred into general practice.¹⁵ The aim of this study was to investigate the sensitivity, specificity and predictive values of spirometry for diagnosing airway obstruction in asthma and COPD in general practice.

Methods

Design and sample: This cross-sectional study was performed between January 2006 and December 2007 with fourteen general practitioners (GPs) working in ten general practices. 219 patients visiting their GP for the first time with complaints suggestive of obstructive airway disease (OAD) were consecutively included in each practice. Patients visited their GPs with symptoms such as dyspnea, coughing or expectoration. Their medical history was taken with a structured questionnaire. The patients had not been diagnosed previously for OAD and they had not received any previous anti obstructive medicine. Other exclusion criteria related to well known contra-indications for bronchodilator reversibility testing or bronchial provocation, namely untreated hyperthyreosis, unstable coronary artery disease, and cardiac arrhythmia. Pregnancy also led to exclusion. The study was approved by the Medical Ethics Committee of the University of Heidelberg. Patients gave written informed consent.

On the basis of the pilot study,¹⁶ we estimated the pre-test probability of asthma as being 45% and of COPD as 16%. We estimated the sensitivity for diagnosing asthma to be 30% and the

specificity to be 90%. The sensitivity and specificity for finding COPD was each estimated to be 90%. Power calculations showed that we had to include at least 208 patients to determine the sensitivities and specificities with a 95% confidence interval of +10%.¹⁷ The diagnostic values of spirometry in general practice were calculated separately for each asthma and COPD group to avoid confusion. The diagnostic value for diagnosing asthma under optimal conditions was investigated by pooling all patients and determining the sensitivity, specificity and predictive values of spirometric maneuvers of the lung function laboratory.

Index test: Spirometry in general practice: Ten general practices were equipped with the same electronic spirometer (Medikro SpiroStar USB) and associated spirometry software. The spirometer was a hand-held instrument for lung function testing that has to be connected via USB device to a computer. Spirometric data, flow-volume and volume-time graphs are displayed in real-time on the personal computer as the patient performs the spirometry test. A calibration file saves the calibration data for internal quality assurance. Instrument performance is regularly monitored and performance deviations are identified by the software. The software also compares the measured values with reference tables. The best of three consecutive spirometry recordings was used in accordance with the guidelines of the European Respiratory Society.¹⁸ The maximal inspiratory and expiratory flow volume curves were generated by forced deep inspiration and expiration with short intervening periods of tidal breathing; patients used a nose clip. The maneuver was performed in a sitting position. Patients with a FEV1 (forced expiratory volume in one second) < 80% of predicted received a bronchodilation test with an additional performance of spirometry 20 minutes after inhaling salbutamol. Obstructive airway disease was diagnosed if FEV1/VC < 70% and/or FEV1 < 80%.^{4,5} Obstruction was considered to be reversible

Table 3: 2 x 2 table of spirometry for diagnosing airway obstruction in patients with COPD (n=208; asthma patients with FEV1<80% of predicted in general practice and in lung function laboratory excluded)

	COPD	No COPD
Spirometry +	44	26
Spirometry –	4	134
Pretest probability of having COPD	23%	208
Pretest probability of not having COPD	77%	
Sensitivity	92% (95%CI 80-97)	
Specificity	84% (95%CI 77-89)	
PPV	63% (95%CI 51-73)	
NPV	97% (95%CI 93-99)	

Table 4: 2 x 2 table of spirometry for diagnosing airway obstruction in patients with asthma in general practice (n=168; patients with COPD excluded)

	asthma	no asthma
Spirometry +	26	8
Spirometry –	63	71
Pretest probability of having asthma	41%	168
Pretest probability of not having asthma	59%	
Sensitivity	29% (95%CI 21-39)	
Specificity	90% (95%CI 81-95)	
PPV	77% (95%CI 60-88)	
NPV	53% (95%CI 45-61)	

Table 5: 2 x 2 table of spirometry for diagnosing airway obstruction in patients with asthma in lung function laboratory (all patients included with differentiation between asthma and COPD)

	asthma	no asthma
Spirometry +	14	0
Spirometry ÅI	76	129
Pretest probability of having asthma	41%	219
Pretest probability of not having asthma	59%	
Sensitivity	16% (95%CI 10-24)	
Specificity	100% (95%CI 97-100)	
PPV	100% (95%CI 79-100)	
NPV	63% (95%CI 56-69)	

Table 6: Agreement between pneumologists' and general practitioners' diagnoses

GP	Asthma	COPD	No OAD	Restrictive lung disease
Pneumologist	n (%)	n (%)	n (%)	n (%)
Asthma (n=90)	69 (76.7)	14 (15.5)	7 (7.8)	0 (0)
COPD (n=50)	7 (16.2)	41 (82.0)	1 (2.7)	1 (0)
No OAD (n=79)	46 (58.2)	8 (10.1)	25 (31.6)	0 (0)

on salbutamol (which indicates a diagnosis of asthma) if the bronchodilation response D FEV1 was $\geq 12\%$ of the baseline and $\geq 200\text{ml}^4$ and norm values were reached. GPs were asked to make their diagnoses based on the test results. All of the GPs were appropriately trained in the key aspects of the diagnosis and management of asthma and COPD, as well as in performing and interpreting spirometry during two educational meetings. The practice assistants completed an intensive 6-hour course and were trained in performing and interpreting spirometry. Two outreach visits were also performed with repeated

individual education at a direct, practical level, until the optimal performance of the spirometry was secured.

Reference test: Bodyplethysmography and bronchial provocation: After diagnosis by their GP, all patients were referred to the lung function laboratory of the University Medical Hospital at once for investigation with whole-body plethysmography (WBP). If therapy was necessary due to asthma or COPD, it was initiated by the GP. However, patients were instructed not to use any bronchodilator or inhaled steroid twelve hours before visiting the lung function laboratory. Spirometry is normally the routine method for measuring the lung volume required to diagnose airflow obstruction—i.e. (forced) vital capacity ((F)VC) or FEV1. However, spirometry is not capable of providing information about intrathoracic residual volume or total airway resistance. A WBP is required to measure residual volume (RV), functional residual capacity (FRC), and total lung capacity (TLC). Therefore, the advantage of WBP over spirometry is that it is able to distinguish between restrictive and obstructive processes. Additionally, the resistance to airflow can be evaluated and the response of airway resistance, airway conductance and thoracic gas volume can be determined in response to bronchodilator reversibility testing and bronchial provocation. In particular circumstances, measurement of these lung volumes are strictly necessary for a correct physiological diagnosis.^{19,20} However, as WBP is only common in highly developed health care systems and the added value on top of spirometry remains unclear, it is only recommended in a few guidelines.²¹⁻²³

Measurement technique of whole-body plethysmography and bronchial provocation:

During WBP, the patient sits inside an airtight chamber and makes respiratory efforts against the closed shutter, causing chest volume to expand and decompressing the air in the lungs. The increase in chest volume reduces the box's volume, thus increasing the pressure in the box. The procedures were performed according to standard protocols.²¹ Lung function reference values that had been adjusted for sex, age, and height were used.²⁴ Patients with FEV1 < 80% of predicted received a bronchodilation test with an additional performance of WBP 20 minutes after inhaling salbutamol. An obstructive airway disease was diagnosed if FEV1 < 80% and/or FEV1/VC < 0.70. The obstruction was classified as reversible on a salbutamol (indicating asthma) when D FEV1 was $\geq 12\%$ and ≥ 200 ml from the baseline value,⁴ and norm values were reached. In all other cases, the obstruction was classified as not reversible (Figure 1). If there was no bronchial obstruction, bronchial provocation was performed to determine bronchial hyper-responsiveness (BHR). Bronchial provocation is considered to be the best method for diagnosing asthma,²⁵ although there is conflicting evidence,²⁶ probably arising from variations in the population studied, as the diagnostic value increases with pre-test probability of the disease.²⁷ Trained lung function technicians measured bronchial hyper-responsiveness to methacholine according to the ATS guideline.⁸ A diagnosis of 'asthma' was made if there was a 20% fall in FEV1 (PC20) from the baseline value after inhaling methacholine stepwise until the maximum concentration (16mg/ml). The pneumologist was blinded against the diagnosis of the GP.

Data analysis: The baseline data were presented descriptively. The sensitivity, specificity, and predictive values of the spirometric investigation (FEV1 and/or FEV1/VC) in general

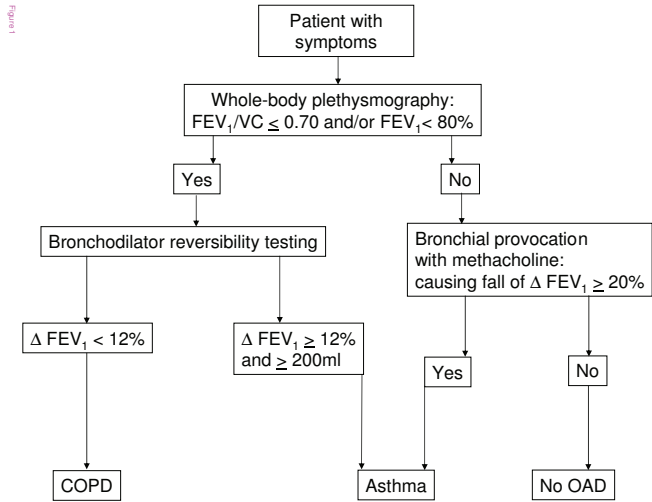


Figure 1: Diagnostic decision making with the reference standard (whole-body plethysmography and bronchial provocation) in the lung function laboratory (COPD = Chronic obstructive pulmonary disease; OAD = obstructive airway disease)

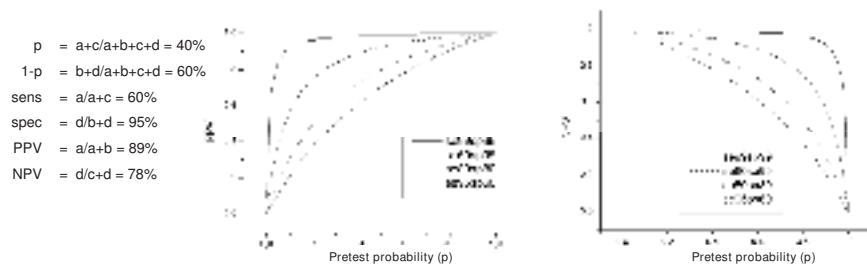
practice were calculated with two-by-two contingency tables with the diagnosis of the pneumologist (WBP and bronchial provocation) as 'gold standard'. The data were analyzed with SPSS 15.0 for Windows. 95% confidence intervals were calculated using Wilson's method²⁸ with the statistical package CIA (Confidence Interval Analysis).²⁹ An explanation of how to interpret PPV and NPV is provided in figure 2.

Results

Study population: A total of 293 patients were assessed for eligibility (Figure 3). 74 patients received spirometry but did not want to receive whole body plethysmography and eventually bronchial provocation. Therefore, altogether 219 patients

Test	Disease		No Disease		
	positive	Right positive a = 72	False positive b = 9	Right negative d = 171	
	negative	False negative c = 48	Right negative d = 171		219
	Total	120	180		300

Pretest probability of having the disease (p): is the prevalence of disease in the investigated population
 Pretest probability of not having the disease (1-p): is the prevalence of healthy subjects in the investigated population
 Sensitivity (sens): is the proportion of people with disease who have a positive test
 Specificity (spec): is the proportion of people free of a disease who have a negative test
 Positive predictive value (PPV): probability that a patient with a positive test has got really the disease
 Negative predictive value (NPV): probability that a patient with a negative test is really healthy



This example illustrates, that a test is useful when the pretest probability is increased up to a reasonable PPV (rule in the disease) or when NPV is increased reasonably (rule out). The figures illustrate that specificity is more important to rule in (spin = specificity rule in); and that sensitivity is more important to rule out (snout = sensitivity rule out). The relation between p, sens, spec, PPV and NPV is described by the Bayes' Theorem. Indeed a test is only useful, if the pretest probability (p) is out of the range of 95%CI of PPV (in this example 95%CI = 80%-94%); and/or if the pretest probability of not having the disease (1-p) is out of the range of the 95%CI of NPV (in this example 95% CI = 72%-83%). The 95%CI is calculated using Wilson's method.²⁸ In this example p is increased up to a meaningful PPV. NPV seems not to be increased reasonably if compared with 1-p.

Figure 2: Calculation example for the relation between pretest probability, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV)

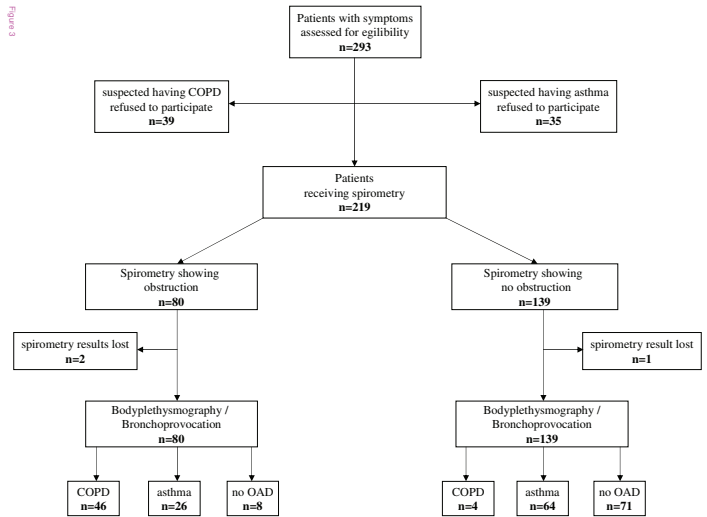


Figure 3: Flow chart of inclusion and diagnostic work up (COPD = Chronic obstructive pulmonary disease; OAD = obstructive airway disease)

participated in the study (127 [57.7%] were female) (Table 1). The average age was 43.8 years. The average body mass index (BMI) was 25.3 (SD 4.4). Of the participating patients, 78 (35.6%) showed airway obstruction in general practice and 138 (63.0%) no abnormal findings in spirometry (Figure 3). Three spirometric results were lost to follow-up. According to the diagnostic decision making in the lung function laboratory, 90 (41.1%) patients had asthma, 50 (22.8%) of the participating patients had irreversible airway obstruction (COPD), and 79 (36.1%) showed no abnormal findings. A diagnosis of asthma was made in 76 of the cases with bronchial provocation, with only 14 patients identified solely on the basis of bronchodilator reversibility testing. The decision that the bronchial provocation was positive was made in 74 cases by 20% fall of FEV1 and in two cases by extreme increase of airway resistance accompanied by development of clinical symptoms of asthma during bronchial provocation. There were no significant differences in sex (p=0.719) or obesity (BMI > 30) (p=0.272) between the diagnoses (chi-square test).

Performance of spirometry in general practice: Spirometry was performed with full adherence to ERS guidelines in 86 (39.8%) cases (Table 2). There was moderate adherence to ERS in 82 (38.0%) cases. In 48 (22.2%) cases the ERS criteria were not fulfilled. E.g., the flow-volume curves were deformed or not exactly reproduced. Altogether, 78 (36.1%) spirometric maneuvers showed airway obstruction. However, a bronchial reversibility test was only performed in 37 (47.4%) of these 78 cases.

Estimates of diagnostic accuracy of spirometry in general practice: In relation to the COPD diagnosis, 26 patients were diagnosed false positive (Table 3). 12 of

these spirometric maneuvers showed full / moderate adherence, and 14 were not according to guidelines. Four patients were diagnosed as false negative as the forced maneuvers in spirometry were performed weakly, thus resulting in a virtually normal Tiffeneau ratio. In these cases was FEV1 > 80% of predicted and FEV1/VC < 0.70 in the WBP as reference standard. Sensitivity was 92% and specificity 84%. Thus the pretest probability could be enhanced reasonably from 23% to a posttest probability (PPV) of 63%; and COPD could be ruled out with high certainty (NPV 97%).

Sixty-three patients with asthma were diagnosed false negative as they showed no abnormal findings in spirometry (Table 4). It was only possible to identify them through bronchial provocation. Eight patients were diagnosed false positive; two of these spirometric maneuvers showed good adherence, and six were not according to guidelines. The pretest probability was enhanced from 41% up to 77%. However, asthma could not be ruled out, since NPV (53%) was similar to the pretest probability of 'not having asthma' (1-p=59%); and 1-p was within the confidence interval of NPV (95%CI 45-61). The spirometric results as a part of the WBP investigation in the lung function laboratory are given in Table 5. Only 14 patients were identified by airway obstruction FEV1 < 80% of predicted and positive bronchial reversibility testing. In addition to this, under these optimal conditions with optimal differentiation between asthma and COPD, the sensitivity for diagnosing asthma solely on basis of spirometric maneuvers was only 16%. Again, NPV was similar to the pretest probability of "not having asthma."

Diagnostic decision making by the GPs: The comparison of the diagnoses by the general practitioners with the diagnoses of the pneumologists demonstrated a reasonable agreement with respect to COPD (Table 6). Additionally, the GPs suspected asthma correctly in 76.7% of asthma cases despite the diagnostic uncertainty using spirometry. Indeed the prevalence of asthma was overestimated with 58.2% of healthy subjects suspected of having asthma; and 7.8% of patients with asthma were considered to be healthy.

Discussion

To our knowledge, this is the first study evaluating the diagnostic accuracy of spirometry for diagnosing airflow obstruction in patients with asthma or COPD in primary care. We found that the use of spirometry is feasible within general practice after training GPs and practice nurses. Under these conditions, the presence or absence of COPD can be estimated with a comparatively high diagnostic accuracy. It is also possible to rule in asthma. However, it was impossible to rule out asthma as the sensitivity was too low.

The prevalence of COPD is increasing in nearly all countries of the world and a high diagnostic accuracy is a prerequisite of optimal therapeutic management. The important role of spirometry for diagnosing airway obstruction has already been demonstrated.^{6,7,30,31} However, the diagnostic accuracy of spirometry for diagnosing COPD has been unknown up to now, thus leading to diagnostic uncertainty in suspected cases of COPD. Our results demonstrate that the pretest-probability of 22% of patients presenting themselves with complaints suggestive of airway obstruction can be increased up to a post-test probability of 63% for having COPD. This comparatively low PPV might be surprising, as the sensitivity was 84% and specificity was 92%. However, this is explainable by the low

pretest probability. Another reason might be due to submaximal maneuvers, leading to false positive results by underestimation of FEV1.¹¹ As a consequence, more efforts in terms of continuous education would be necessary for an improvement of performance and an interpretation of spirometry. Nevertheless, COPD can be definitively excluded (NPV 97%) when spirometry is performed optimally. For these reasons, spirometry should be used regularly for diagnosing and managing COPD in primary care.

In contrast to these promising results is the limited value of spirometry in excluding asthma. This might be explained by the reversibility of airway obstruction in asthma. It proved possible to speculate that patients with mild or moderate asthma show no airway obstruction when spirometry is performed. In these cases, it was necessary for the GP to estimate the presence or absence of asthma on the basis of the patient history and inconclusive spirometry. This was misleading in 53 (24.2%) of cases (46 patients false positive and 7 patients false negative). Therefore, alternative methods need to be found for diagnosing asthma in primary care. Guidelines recommend using the measurement of peak-flow-variability to diagnose asthma in case of inconclusive spirometry. However, the low diagnostic value of peak-flow-variability in primary care has already been demonstrated.³² The SAPALDIA study, which used an epidemiologic approach, has also shown a poor diagnostic value.³³ The measurement of exhaled nitric oxide (NO) which is elevated in eosinophilic airway inflammation³⁴ has been shown to be more promising,³⁵ although the technology is expensive. Therefore, patients suspected of having asthma might be tested with NO measurement or should be referred for bronchial provocation if possible to guarantee accurate diagnosis. Nevertheless, spirometry should be used in diagnosing asthma, as the positive predictive value has been comparatively high in general practice.

One important limitation was that 22% of the spirometric maneuvers were not performed correctly in general practice. However, with the analysis of the spirometric maneuvers as part of the WBP investigation in the lung function laboratory, we received accurate diagnostic values of spirometry. Our results revealed that the predictive values of general practice were slightly lower than in the lung function laboratory. In addition to this, it was not possible to include all patients consecutively, as some patients were not willing to travel to the lung function laboratory of the Medical Hospital. This might have led to an overestimation of the diagnostic accuracy of spirometry.³⁶ However, that would also emphasize the impossibility of excluding asthma solely with spirometry. Another limitation is due to the choice of the cut-off points. Our use of the ratio FEV1/VC < 0.70 as is still recommended by GOLD⁵ may have led to some overestimation of airway obstruction in older patients³⁷ and underestimation in younger patients.³⁸ The ATS/ERS guideline therefore suggests using lower limits of normal, which is statistically defined by the 5th lower percentile of a reference population, to provide more accurate diagnoses.¹⁹ This diagnostic algorithm was not integrated in the spirometric software at the time of our study. Moreover, we are aware of the limitations of a one-off lung function test to determine a final diagnosis, as a negative bronchodilator response can occur due to fixed airway obstruction in asthma. A trial of steroids might have been necessary to differentiate between asthma and COPD in some patients. Nevertheless, these limitations do not hamper our finding that asthma cannot be excluded

solely with spirometry. The WBP showed little added value on top of spirometry. We used it as a reference standard to distinguish between overlapping diseases, COPD and restrictive lung disorder. However, we only experienced two changes in making the diagnosis with the added information of WBP. In two patients suffering from dyspnea attacks, the airway resistance was very high during bronchial provocation, but FEV1 remained normal. Moreover, we found no patient with restrictive lung disorder, which indicates a low prevalence in primary care settings. Therefore, the added value of WBP for primary care is limited and it should be reserved for patients who are difficult to diagnose and show persistent complaints.

It was not possible to specify the alternate diagnosis of the patients with no OAD, which is a typical problem of diagnostic studies in primary care. It was impossible to perform every investigation (e.g. gastroscopy to determine gastro-oesophageal reflux; x-ray) until a definite diagnosis could be made. This would not have been allowed by the Ethics Committee. However, this limitation does not alter the results of spirometric investigation. Finally, the participating GPs and practice assistants were highly motivated and received intensive training. Nevertheless, 22% of the spirometric maneuvers showed no guideline adherence. In particular bronchodilation testing was not performed regularly which might be due to organisational reasons and time constraints in general practice. The GPs estimated fourteen patients to suffer from COPD. However, the final pneumologists' diagnosis of these patients was asthma due to positive bronchodilator testing. Therefore, this lack of performance led the GPs to over-estimate COPD and under-estimate asthma in patients with airway obstruction. This is of importance as patients with asthma need to be treated preferably with inhaled steroids. However, our results are better than demonstrated by Miravittles et al.,³⁹ which might be due to the repeated education of the whole practice team. Nevertheless, these results are not satisfying enough. Further efforts are necessary to improve the performance of spirometry, as this could enhance the diagnostic accuracy. It has already been established that GPs are able to perform and interpret spirometry after educational meetings⁴⁰ and that performing spirometry has a positive impact on medical decision making.^{6,30,41} It therefore seems reasonable and valuable to implement high quality spirometry in primary care. Conclusions

COPD can be estimated with high diagnostic accuracy using spirometry. It is also possible to rule in asthma with spirometry. However, asthma can not be ruled out only using spirometry. This diagnostic uncertainty leads to an overestimation of asthma presence. Patients with inconclusive spirometric results should be referred for NO—measurement and/or bronchial provocation if possible to guarantee accurate diagnosis.

References

- 1 Tattersfield AE, Knox AJ, Britton JR, Hall IP: Asthma. *Lancet* 2002, 360: 1313-1322.
- 2 Calverley PM, Walker P: Chronic obstructive pulmonary disease. *Lancet* 2003, 362: 1053-1061.
- 3 Murray CJ, Lopez AD: Alternative projections of mortality and disability by cause 1990-2020: Global Burden of Disease Study. *Lancet* 1997, 349: 1498-1504.
- 4 National Institute of Health: Global Initiative for Asthma—Global Strategy for Asthma Management and Prevention (GINA). www.ginasthma.com: 2008.
- 5 National Institute of Health: Global Initiative for Chronic Obstructive Lung Disease (GOLD). www.goldcopd.com: 2008.
- 6 Walker PP, Mitchell P, Diamantea F, Warburton CJ, Davies L: Effect of primary-care spirometry on the diagnosis and management of COPD. *Eur Respir J* 2006, 28: 945-952.
- 7 Buffels J, Degryse J, Heyrman J, Decramer M: Office spirometry significantly improves early detection of COPD in general practice: the DIDASCO Study. *Chest* 2004, 125: 1394-1399.
- 8 Crapo RO, Casaburi R, Coates AL, Enright PL, Hankinson JL, Irvin CG, MacIntyre NR, McKay RT, Wanger JS, Anderson SD, Cockcroft DW, Fish JE, Sterk PJ: Guidelines for methacholine and exercise challenge testing-1999. This official statement of the American Thoracic Society was adopted by the ATS Board of Directors, July 1999. *Am J Respir Crit Care Med* 2000, 161: 309-329.
- 9 Thiadens HA, de Bock GH, Dekker FW, Huysman JA, Van Houwelingen JC, Springer MP, Postma DS: Identifying asthma and chronic obstructive pulmonary disease in patients with persistent cough presenting to general practitioners: descriptive study. *BMJ* 1998, 316: 1286-1290.
- 10 van den Boom G, van Schayck CP, van Mollen MP, Tirimanna PR, den Otter JJ, van Grunsven PM, Buitendijk MJ, van Herwaarden CL, van Weel C: Active detection of chronic obstructive pulmonary disease and asthma in the general population. Results and economic consequences of the DIMCA program. *Am J Respir Crit Care Med* 1998, 158: 1730-1738.
- 11 Derom E, van Weel C, Liistro G, Buffels J, Schermer T, Lammers E, Wouters E, Decramer M: Primary care spirometry. *Eur Respir J* 2008, 31: 197-203.
- 12 Poels PJ, olde Hartman TC, Schermer TR, Albers M, van Weel C: Influence of spirometry on patient management in diagnostic studies unknown. *Chest* 2006, 129: 1733-1734.
- 13 Ledley RS, Lusted LB: Reasoning foundations of medical diagnosis; symbolic logic, probability, and value theory aid our understanding how physicians reason. *Science* 1959, 130: 9-21.
- 14 O'Connor GT, Sox HC, Jr.: Bayesian reasoning in medicine: the contributions of Lee B. Lusted, MD. *Med Decis Making* 1991, 11: 107-111.
- 15 Knottnerus JA, van Weel C, Muris JW: Evaluation of diagnostic procedures. *BMJ* 2002, 324: 477-480.
- 16 Schneider A, Dinant GJ, Maag I, Gantner L, Meyer FJ, Szecsenyi J: The added value of C-reactive protein to clinical signs and symptoms in patients with obstructive airway disease: results of a diagnostic study in primary care. *BMC Fam Pract* 2006, 7: 28.
- 17 Simel DL, Samsa GP, Matchar DB: Likelihood ratios with confidence: sample size estimation for diagnostic test studies. *J Clin Epidemiol* 1991, 44: 763-770.
- 18 Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, Crapo R, Enright P, van der Grinten CP, Gustafsson P, Jensen R, Johnson DC, MacIntyre N, McKay R, Navajas D, Pedersen OF, Pellegrino R, Viegi G, Wanger J: Standardisation of spirometry. *Eur Respir J* 2005, 26: 319-338.
- 19 Pellegrino R, Viegi G, Brusasco V, Crapo RO, Burgos F, Casaburi R, Coates A, van der Grinten CP, Gustafsson P, Hankinson J, Jensen R, Johnson DC, MacIntyre N, McKay R, Miller MR, Navajas D, Pedersen OF, Wanger J: Interpretative strategies for lung function tests. *Eur Respir J* 2005, 26: 948-968.
- 20 Wanger J, Clausen JL, Coates A, Pedersen OF, Brusasco V, Burgos F, Casaburi R, Crapo R, Enright P, van der Grinten CP, Gustafsson P, Hankinson J, Jensen R, Johnson D, MacIntyre

- N, McKay R, Miller MR, Navajas D, Pellegrino R, Viegi G: Standardisation of the measurement of lung volumes. *Eur Respir J* 2005, 26: 511-522.
- 21 American Association for Respiratory Care: AARC clinical practice guideline. Body plethysmography: 2001 revision and update. *Resp Care* 2001, 46: 506-513.
 - 22 Siafakas NM, Vermeire P, Pride NB, Paoletti P, Gibson J, Howard P, Yernault JC, Decramer M, Higenbottam T, Postma DS, .: Optimal assessment and management of chronic obstructive pulmonary disease (COPD). The European Respiratory Society Task Force. *Eur Respir J* 1995, 8: 1398-1420.
 - 23 Vogelmeier C, Buhl R, Criece CP, Gillissen A, Kardos P, Kohler D, Magnussen H, Morr H, Nowak D, Pfeiffer-Kascha D, Petro W, Rabe K, Schultz K, Sitter H, Teschler H, Welte T, Wettengel R, Worth H: Guidelines for the diagnosis and therapy of COPD issued by Deutsche Atemwegsliga and Deutsche Gesellschaft für Pneumologie und Beatmungsmedizin. *Pneumologie* 2007, 61: e1-40.
 - 24 Quanjer PH: EGKS: standardized lung function testing. *Bull Eur Physiopathol Respir* 1983, 5: 1-92.
 - 25 Hunter CJ, Brightling CE, Woltmann G, Wardlaw AJ, Pavord ID: A comparison of the validity of different diagnostic tests in adults with asthma. *Chest* 2002, 121: 1051-1057.
 - 26 James A, Ryan G: Testing airway responsiveness using inhaled methacholine or histamine. *Respirology* 1997, 2: 97-105.
 - 27 Perpina M, Pellicer C, de Diego A, Compte L, Macian V: Diagnostic value of the bronchial provocation test with methacholine in asthma. A Bayesian analysis approach. *Chest* 1993, 104: 149-154.
 - 28 Wilson EB: Probable inference, the law of succession, and statistical inference. *J Am Stat Assoc* 1927, 22: 209-212.
 - 29 Altman DG, Machin D, Bryant TN, Gardner MJ: *Statistics with confidence*, 2 edn. London: BMJ Books; 2000.
 - 30 Dales RE, Vandemheen KL, Clinch J, Aaron SD: Spirometry in the primary care setting: influence on clinical diagnosis and management of airflow obstruction. *Chest* 2005, 128: 2443-2447.
 - 31 Dales RE, Aaron SD, Vandemheen KL, Mehdizadeh A, Clinch J: The prevalence of airflow obstruction in rural primary care. *Respir Med* 2006, 100: 754-759.
 - 32 den Otter JJ, Reijnen GM, van den Bosch WJ, van Schayck CP, Molema J, van Weel C: Testing bronchial hyper-responsiveness: provocation or peak expiratory flow variability? *Br J Gen Pract* 1997, 47: 487-492.
 - 33 Kunzli N, Stutz EZ, Perruchoud AP, Brandli O, Tschopp JM, Bolognini G, Karrer W, Schindler C, Ackermann-Lieblich U, Leuenberger P: Peak flow variability in the SAPALDIA study and its validity in screening for asthma-related conditions. The SPALDIA Team. *Am J Respir Crit Care Med* 1999, 160: 427-434.
 - 34 Kharitonov SA, Yates D, Robbins RA, Logan-Sinclair R, Shinebourne EA, Barnes PJ: Increased nitric oxide in air of asthmatic patients. *Lancet* 1994, 343: 133-135.
 - 35 Schneider A, Tilemann L, Schermer T, Gindner L, Laux G, Szecsenyi J, Meyer FJ: Diagnosing asthma in general practice with portable exhaled nitric oxide measurement—results of a prospective diagnostic study. *Respir Res* 2009, 10: 15.
 - 36 Whiting P, Rutjes AW, Reitsma JB, Glas AS, Bossuyt PM, Kleijnen J: Sources of variation and bias in studies of diagnostic accuracy: a systematic review. *Ann Intern Med* 2004, 140: 189-202.
 - 37 Schermer TR, Smeele IJ, Thoonen BP, Lucas AE, Grootens JG, van Boxem TJ, Heijdra YF, van Weel C: Current clinical guideline definitions of airflow obstruction and COPD overdiagnosis in primary care. *Eur Respir J* 2008, 32: 945-952.
 - 38 Cerveri I, Corsico AG, Accordini S, Niniano R, Ansaldo E, Anto JM, Kunzli N, Janson C, Sunyer J, Jarvis D, Svanes C, Gislason T, Heinrich J, Schouten JP, Wjst M, Burney P, de Marco R: Underestimation of airflow obstruction among young adults using FEV1/FVC <70% as a fixed cut-off: a longitudinal evaluation of clinical and functional outcomes. *Thorax* 2008, 63: 1040-1045.
 - 39 Miravittles M, de la RC, Naberan K, Lamban M, Gobartt E, Martin A: Use of spirometry and patterns of prescribing in COPD in primary care. *Respir Med* 2007, 101: 1753-1760.
 - 40 Schermer TR, Jacobs JE, Chavannes NH, Hartman J, Folgering HT, Bottema BJ, van Weel C: Validity of spirometric testing in a general practice population of patients with chronic obstructive pulmonary disease (COPD). *Thorax* 2003, 58: 861-866.
 - 41 Chavannes N, Schermer T, Akkermans R, Jacobs JE, van de GG, Bollen R, van Schayck O, Bottema B: Impact of spirometry on GPs' diagnostic differentiation and decision-making. *Respir Med* 2004, 98: 1124-1130.

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What are the indications for the appropriateness of home sleep testing?

A home sleep test would be appropriate if a consultation or a sleep screener questionnaire indicates that a patient has moderate to severe OSA, provided there is no significant presence of a co-morbid condition or symptoms that indicate other sleep disorders. Patients already diagnosed with apnea can also benefit from a home sleep test in order to monitor their responsiveness to treatment.

How are your products integrated for hybrid labs?

Embla has products to accommodate any combination of sleep testing models. A sleep lab offering full in-lab studies as well as home sleep testing can take full advantage of the efficiency tools available with their Embla system. Our RemLogic-Go software features quick and easy study setup, effortless transfer of studies over a network for remote scoring, and automatic tracking of all downloaded studies. In addition, the RemLogic CPC module can be used for both PSG and PG studies, and our Enterprise Business Management software can be used to track and manage patient information throughout the continuum of care, allowing all patient information and history to reside in one location despite the number of studies performed, the type of study performed, or the location where the study was performed.

Associations Between Statins and COPD: A Systematic Review

Claudia C. Dobler, Keith K. Wong, Guy B. Marks

Abstract

Background: Statins have anti-inflammatory and immunomodulating properties which could possibly influence inflammatory airways disease. We assessed evidence for disease modifying effects of statin treatment in patients with chronic obstructive pulmonary disease (COPD).

Methods: A systematic review was conducted of studies which reported effects of statin treatment in COPD. Data sources searched included MEDLINE, EMBASE and reference lists.

Results: Eight papers reporting nine original studies met the selection criteria. One was a randomized controlled trial (RCT), one a retrospective nested case-control study, five were retrospective cohort studies of which one was linked with a case-control study, and one was a retrospective population-based analysis. Outcomes associated with treatment with statins included decreased all-cause mortality in three out of four studies (OR/HR 0.48-0.67 in three studies, OR 0.99 in one study), decreased COPD-related mortality (OR 0.19-0.29), reduction in incidence of respiratory-related urgent care (OR 0.74), fewer COPD exacerbations (OR 0.43), fewer intubations for COPD exacerbations (OR 0.1) and attenuated decline in pulmonary function. The RCT reported improvement in exercise capacity and dyspnea after exercise associated with decreased levels of C-reactive protein and Interleukin-6 in statin users, but no improvement of lung function. **Conclusions:** There is evidence from observational studies and one RCT that statins may reduce morbidity and/or mortality in COPD patients. Further interventional studies are required to confirm these findings.

Background

Chronic obstructive pulmonary disease (COPD) is a common disease with a high burden to society on a worldwide scale.¹ Only smoking cessation² and long-term oxygen therapy, in patients with resting hypoxemia while awake,^{3,4} clearly alter prognosis for survival or decline in lung function. The lack of potent treatment options for COPD patients contrasts with the development of new treatments in other high burden chronic diseases like cardiovascular disease. Several drugs, in particular statins, have been shown to improve prognosis after acute coronary events during the last 20 years.⁵

The authors are with the Woolcock Institute of Medical Research. Dobler and Marks are also with the Department of Respiratory Medicine, Liverpool Hospital, Sydney; Marks is also with the South Western Sydney Clinical School, University of New South Wales, Australia. Reprinted from BioMed Central, BMC Pulmonary Medicine, © 2009 Dobler et al, licensee BioMed Central Ltd. This is an open access article distributed under the terms of the Creative Commons Attribution License. This article has been slightly edited for our readers.

Recently statins have emerged as a possible disease modifying agent in COPD. The rationale for this at least partly derives from the fact that the pathogenesis of COPD involves inflammatory processes,⁶ and persistent systemic inflammation seems to be present even in patients with stable COPD who do not currently smoke.⁷ Lee et al. showed that simvastatin ameliorated the structural and functional derangement of rat lungs caused by cigarette smoking, partly by suppressing inflammation and matrix metalloproteinase-9 induction and preventing pulmonary vascular abnormality.⁸ Statins possess pleiotropic effects in addition to their conventional lipidlowering properties including anti-inflammatory, antioxidant, antithrombotic and vascular function-restoring actions.^{9,10,11} For example they have been shown to have a beneficial effect in sepsis and pneumonia.^{12,13}

There are reports from observational studies that statins may reduce morbidity and mortality in COPD patients. Whether statins have a beneficial effect in COPD patients by primarily reducing cardiovascular complications or because they exhibit an action directly targeting pulmonary inflammation is, however, a matter of controversy. We conducted a systematic review to find evidence for our hypothesis that statin treatment has a disease modifying effect in patients with COPD and improves a) morbidity and b) mortality.

Methods

We searched the published English-language literature to identify studies that examined the effect of statins in patients with COPD. We searched two electronic databases: MEDLINE through OvidSP and PubMed (1950-31st October 2008) and EMBASE through OvidSP (1980-31st October 2008). On reviewing the selected titles and abstracts we retained publications reporting clinical or laboratory outcome measurement in COPD patients treated with statins. Studies in which outcomes of treatment with statins were examined for a subgroup of subjects with COPD or obstructive pulmonary function were also included. Only articles reporting original data were retained; abstracts, editorials and letters were excluded. The full text of [relevant] papers were then retrieved and reviewed to confirm eligibility. Disagreements between the reviewers were resolved by consensus. Studies were eligible for inclusion if they were primary articles reporting an association between statin treatment and clinical or laboratory outcomes in COPD patients. We extracted information on study objective, study design, inclusion and exclusion criteria for participants, COPD definition for the study purpose, details on statin treatment, use of corticosteroids, smoking status, cardiovascular comorbidities in participants, duration of follow-up, and outcome measurements. Specific attention was given to the inclusion or exclusion of patients with asthma. Details on statin treatment included type of statin, dosage, duration of treatment and adherence to treatment.

Table 1. Characteristics of included studies

Author, place, date of publication	Study design	Study purpose	Statin exposed group	Controls	Outcome measurements
Lee T-M, et al., Taiwan, 2008 [19]	Randomized, double-blinded, placebo-controlled trial	To investigate whether pravastatin administration is effective in improving exercise capacity in patients with COPD, and whether baseline or serial changes in hs-CRP over time are associated with corresponding changes in exercise capacity.	n=62 patients with clinically stable COPD, received pravastatin (40 mg/day) over a period of 6 months (randomly assigned, double blind).	n=63 patients with clinically stable COPD, received placebo over a period of 6 months (randomly assigned, double blind).	Exercise capacity CRP/IL-6 Secondary outcome measurements: Lung function Borg dyspnea score after exercise tests
Blamoun AI et al, USA, 2008 [27]	Cohort study	To assess the rate of COPD exacerbations and intubations in COPD patients taking statins	n= 90 patients with primary or secondary diagnosis of COPD who were taking statins at the time of hospital admission and during the 1-year follow-up	n= 95 patients with primary or secondary diagnosis of COPD who were not taking statins at the time of hospital admission and during the 1-year follow-up	COPD exacerbations Intubations secondary to COPD exacerbation
Van Gestel YR et al., Netherlands, 2008 [21]	Cohort study	To examine the relation between statins and mortality (within 30 days and 10 years) in a group of patients who underwent surgery for peripheral arterial disease and compare results in those with versus without associated COPD	COPD group: n=330 COPD patients who underwent elective vascular surgery and who did use statins	COPD group: n=980 COPD patients who underwent elective vascular surgery and who did use statins	All-cause mortality, short- and long-term (within 30 days and 10 years of follow-up respectively)
Søyseth V et al., Norway, 2007 [22]	Cohort study	To determine whether statins alone or in combination with inhaled steroids improve survival after COPD exacerbation	n=118 patients with a diagnosis of COPD exacerbation at hospital discharge who were taking statins at the time of discharge	n=736 patients with a diagnosis of COPD exacerbation at hospital discharge who were not taking statins at the time of discharge	All-cause mortality
Frost FJ et al., USA, 2007 [20]	Cohort study, and separate case-control studies (for influenza and COPD deaths)	To assess whether statin users have reduced mortality risks from influenza and COPD	Cohort study: n=19,058; patients with statin exposure Case control study: n= 207; COPD deaths (in hospital)	Cohort study: n= 57,174; patients with no history of statin therapy Case-control study: n=9,622; surviving patients with either an inpatient or outpatient diagnosis of COPD	Mortality from COPD (and influenza, not included in this review)
Keddissi JI, et al., USA, 2007 [26]	Cohort study	To assess the ability of statins to preserve lung function in current and former smokers and to reduce the incidence of respiratory-related urgent care	n=215; statin users who were smokers or ex-smokers and had abnormal baseline spirometry (majority with obstructive spirometry findings, but restrictive findings also included).	n=203; non-statin users who were smokers or ex-smokers and had abnormal baseline spirometry (obstruction or restriction)	Lung function (annual decline in FEV1 and FVC) Respiratory-related ED-visits and hospitalizations
Mancini GB et al., Canada, 2006 [25]	Nested case-control study (time-matched)	To determine if statins, angiotensin-converting enzyme-inhibitors and angiotensin receptor blockers reduce total mortality, COPD hospitalisations and myocardial infarctions in COPD patients	Two distinct COPD cohorts: 1) n=2983 (sum of cases analysed for different endpoints, n=3231 when steroid users included), high cardiovascular risk cohort (COPD patients having undergone coronary revascularization) 2) n=7617 (sum of cases analysed for different endpoints, n=8240 when steroid users included), low cardiovascular risk cohort (COPD patients without previous myocardial infarction and newly treated with nonsteroidal anti-inflammatory drug)	from same databases as study population, matched for age and year of cohort entry and still at risk of the event (endpoint) n= 59,170 for cohort 1 (sum of controls for different endpoints, n= 64,185 including steroid users) n= 152,177 for cohort 2 (sum of controls for different endpoints, n= 164,672 including steroid users)	COPD hospitalizations Myocardial infarction All-cause mortality
Ishida W, et al., Japan, 2007 [23]	Ecological analysis	To assess effects of statin use on mortality from major causes of death (cardiovascular diseases, COPD, pneumonia etc.)	COPD deaths in the >65 yrs old population in each of the 47 prefectures of Japan	No control	Mortality from COPD (and other major diseases), related to statin sales in the same area

Table 2. Association of statin treatment with continuous outcome variables

Study	Outcome	Parameter estimate and 95% confidence interval
Mortality 2° to COPD		
Ishida W, et al., Japan, 2007 [23]	Decreased mortality 2° to COPD in statin users	Inverse correlation between statin prescriptions dispensed and mortality due COPD by prefecture, $p < 0.0001$
Respiratory-related urgent care		
Keddissi JI, et al., USA, 2007 [26]	Reduction in respiratory-related emergency-department-visits and/or hospitalizations in statin users	Incidence of respiratory related urgent care, obstructive spirometry group 0.12 ± 0.29 /patient-yr in statin users versus 0.19 ± 0.32 /patient-yr in control, $p = 0.02$
Lung function		
Keddissi JI, et al., USA, 2007 [26]	Lower decline in FEV1 and FVC/yr in statin users	Obstructive spirometry group change in FEV1 $+5 \pm 207$ ml/yr in statin users change in FEV1 -86 ± 168 ml/yr in control ($p < 0.0001$) change in FVC $+33 \pm 452$ ml/yr in statin users change in FVC -150 ± 328 ml/yr in control ($p < 0.0001$)
Lee T-M, et al., Taiwan, 2008 [19]	No difference in pulmonary function parameters in statin users	Pravastatin group: FEV1% at baseline 51 ± 18 , at follow-up 55 ± 19 Placebo group: FEV1% at baseline 56 ± 13 , at follow-up 55 ± 14 , $p > 0.05$
Exercise capacity		
Lee T-M, et al., Taiwan, 2008 [19]	Improvement in exercise time in statin users	Pravastatin group: exercise time in s at baseline 599 ± 323 , at follow-up 922 ± 328 Placebo group: exercise time in s at baseline 608 ± 273 , at follow-up 609 ± 180 , $p < 0.05$
Borg dyspnea score after exercise tests		
Lee T-M, et al., Taiwan, 2008 [Error! Bookmark not defined.]	Lesser degree of dyspnea after exercise in statin users	Pravastatin group: Borg dyspnea score at baseline 7.0 ± 0.8 , at follow-up 4.0 ± 0.7 Placebo group: Borg dyspnea score at baseline 6.9 ± 0.8 , at follow-up 6.9 ± 1.0 , $p < 0.05$
CRP/ IL-6 levels		
Lee T-M, et al., Taiwan, 2008 [Error! Bookmark not defined.]	Decrease in CRP/IL-6 levels in statin users	Pravastatin group: CRP (mg/l) at baseline 3.94 ± 3.54 , at follow-up 3.85 ± 2.56 Placebo group: CRP (mg/l) at baseline 4.06 ± 2.67 , at follow-up 2.66 ± 2.49 , $p < 0.05$

The RCT was assessed for evidence of concealed randomization, similarity of the randomized groups at baseline, standardization of non-intervention treatment strategies between treatment groups, blinding of patients and investigators, number of crossovers, intention-to-treat analysis, follow-up to the defined outcome, and generalizability of the conclusions of the trial to other populations.¹⁴ Observational studies were evaluated for internal validity based on adequate description of patient characteristics (including age, definition of COPD and cardiovascular comorbidities), adequate description of treatment strategy (statin type, dosage, duration of treatment) and follow-up. They were also assessed for external validity using a qualitative determination of the degree to which the findings of the study could be generalized to other populations.¹⁵

Results

Overall, 785 citations were identified, from which 21 articles were selected for review (Fig 1). Of these, 10 were excluded because they were reviews, letters or comments. Three original articles did not meet the inclusion criteria. One study, which examined the effect of statin use on lung function in elderly patients with various smoking histories, was excluded, because there was no specific analysis for patients with COPD or

obstructive pulmonary function test findings published.¹⁶ We excluded one study that examined the effect of statins in patients with asthma,¹⁷ and another study that reported the effects of statin use on lung transplant recipients.¹⁸ A total of 8 papers reporting 9 studies met the inclusion criteria (Table 1). They were all published between 2006 and 2008 and reported effects of statin treatment on patients with COPD. Only one study was a randomized controlled trial (RCT). The other studies were analyses of observational data and included one nested case-control study, five historical cohort studies of which one was linked with a case-control study, and one ecological study.

Data on the association of statin treatment with continuous outcome variables are presented in Table 2. Effect estimates for binary outcomes are presented in Fig 2. Three cohort studies reported decreased all-cause mortality in patients treated with statins, whereas no difference in all-cause mortality between statin users and non-statin users was found in one cohort study. Another cohort study and the linked case-control study showed a decrease in deaths attributed to COPD. The ecological analysis found less COPD mortality in areas with high statin use. A reduction in incidence of respiratory-related urgent care with statin use was found in two studies. One cohort study found fewer COPD exacerbations and

fewer required intubations secondary to COPD in patients who were taking statins. One observational study reported attenuated decline in pulmonary function parameters in statin users, whereas the only interventional study did not find a difference in lung function in statin users after six months of treatment. However, the RCT reported improvement in exercise capacity and dyspnea after exercise associated with decreased levels of CRP and IL-6 in statin users.

The RCT¹⁹ described allocation concealment and similarity of the groups at baseline. Treatment strategies were standardized between the treatment groups, patients and investigators were blinded and an intention-to-treat analysis was performed. Subject retention to outcome assessment was 86% after 6 months (18 out of 125 patients withdrew during the study).

The observational studies that were analyzed all had adequate description of patient characteristics including details on patients' age and definition of COPD for study purposes. All studies (except for the study by Frost et al²⁰) described cardiovascular comorbidities. Descriptions of treatment strategies lacked details regarding type of statin used and dosage. The study by van Gestel et al²¹ had the most

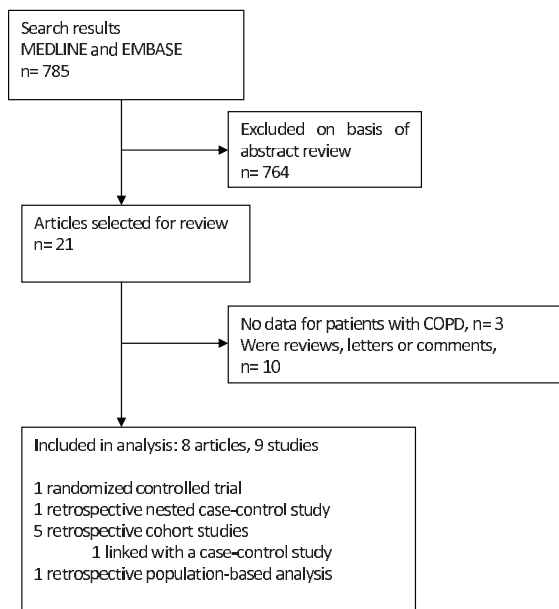


Fig 1. Study selection process

comprehensive description of treatment strategy and also documented very good follow-up of 96%. The issue of external validity or generalizability of the findings is dealt with in the next section.

Key differences between included studies

Definition of COPD: Different criteria were applied for definition of COPD. The majority of studies relied on a patient chart diagnosis of COPD. Those studies using health system data identified COPD based on one or more of the following recorded codes from the International Classification of Disease: ICD-10 J41-44 or ICD-9 490-496.^{20,22,23} In one of these studies spirometric data were also available and only 88% had a FEV1/FVC ratio < 0.7,²² which means that 12% of the cohort patients with spirometry results available did not meet the GOLD criteria²⁴ for the definition of COPD. Patients with COPD were identified through medication use in one study.²⁵ The cohort study by Keddissi et al.,²⁶ the study by van Gestel et al.²¹ and the RCT¹⁹ applied lung function criteria (FEV1/FVC < 70%) for the definition of obstructive lung disease. However, in the study by Keddissi et al. there was a discrepancy between 169 patients (40%) that had a COPD diagnosis based on information from medical records, compared to 319 patients (76%) who were found to have obstructive baseline spirometry. Hence, “COPD populations” analysed in those studies that did not use lung function criteria may differ from people with COPD defined in accordance with GOLD criteria.²⁴

Exclusion of asthma patients: Three studies used specific exclusion criteria to avoid inclusion of subjects who had a primary diagnosis of asthma. Mancini et al.²⁵ excluded all patients who had used at least one prescription of an inhaled steroid, nasal steroid, and other drugs including nedocromil, ketotifen, and cromoglycate during the year preceding cohort entry. However, they performed a separate analysis for a COPD cohort including users of oral or inhaled steroids (but not nasal steroids). Results were similar when steroid users were included. In the study by Keddissi et al.²⁶ patients with a clinical history of asthma were excluded. Yet, as the authors of the paper state, it was still possible that some included patients had an asthmatic

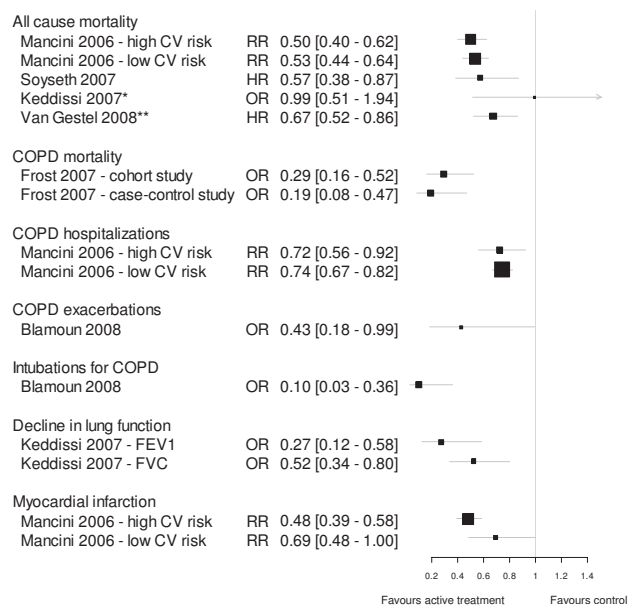


Fig 2. Forest plot of effect estimates of statins for ORs, HRs and RRs
Legend: RR=Risk ratio, HR=Hazard ratio, OR=Odds Ratio, where available, adjusted estimates (OR, HR, RR) were used. Values less than 1 indicate a better outcome with statin therapy. Box size is proportional to precision of the estimate.
*Mortality was only given for the whole cohort, which included 24% patients with restrictive rather than obstructive spirometry finding.
**10-year mortality (mortality at 30 days not shown)

component to their lung disease, particularly when taking into account that 3-6% of all cohort patients were receiving leukotriene inhibitors. Lee et al.¹⁹ excluded patients with one or more of the following features (possibly indicating a diagnosis of asthma): a history of perennial allergic rhinitis, periodic wheezing and an improvement in FEV1 of >15% after inhalation of a bronchodilator.

Concomitant use of steroids: A number of studies examined whether the inclusion of corticosteroid-steroid users altered the findings. Other simply reported on the use of corticosteroids in the study population. The studies by Mancini et al.²⁵ and Søyseth et al.²² showed that use of inhaled corticosteroids did not modify the effect of statins on mortality (or the other outcomes measured in Mancini's study). However, the study by Søyseth et al. reported an additive benefit on mortality when statins and inhaled corticosteroids were combined. In the lung function study by Keddissi et al.²⁶ there was no difference in the use of inhaled or systemic corticosteroids or immunosuppressive therapy between the statin group and the controls. For the whole cohort (including 76% with obstructive pulmonary function test findings and 24% with restrictive pulmonary function test patterns) the change in FEV1 was associated with both statin use and the use of steroids. The change in FVC was associated with statin use, the use of nonsteroidal anti-inflammatory drugs/aspirin and the use of β -blockers. In the RCT from Taiwan¹⁹ 48% of patients in the pravastatin group and 52% in the placebo group were described as steroid dependent at baseline. All medications for COPD were kept constant throughout the study period of 6 months. Modification of the effect of statins by corticosteroids was not evaluated.

Smoking status: The smoking status of participants was reported in 5 studies. The study by Søyseth et al.²² included

6.9% of patients who had never smoked, 37.5% former smokers, 51.8% current smoker and 3.9% had missing data. No definition for who qualified as former smoker (duration of smoking abstinence) was given. The age-adjusted relative mortality was lower in statin users than nonusers in the subgroups of never smokers and current smokers, but not former smokers. Keddissi et al.²⁶ excluded never smokers in their study. Sixty-five % of their study participants were ex-smokers (defined as patients that quit smoking at least 6 months prior to the last pulmonary function test), 35% were current smokers. The beneficial effect of statins on lung function decline was apparent in both the current smoker and the ex-smoker groups with no significant difference between the groups. The cohort study that analysed exacerbations and intubations for exacerbations of COPD,²⁷ the study that looked at mortality in COPD patients that underwent elective vascular surgery²¹ and the interventional study by Lee et al.¹⁹ gave information on smoking status of participants, but did not include subgroup analysis based on smoking status.

Cardiovascular risk profile: In the RCT by Lee et al.¹⁹ no characteristics of the patients regarding cardiovascular risks were described. Mancini et al.²⁵ looked at COPD patients with different cardiovascular risk profiles. One cohort consisted of revascularized patients (percutaneous coronary angioplasty and/or bypass grafting), whereas a second cohort specifically excluded any patients with a myocardial infarction in the five years preceding cohort entry. The study found that the risk reduction for COPD hospitalizations and all-cause mortality with statin treatment was similar in both groups. However, there was no apparent beneficial effect on prevention of myocardial infarction in the low cardiovascular risk group. In the Norwegian retrospective cohort study by Søyseth et al.²² nearly 30% of all study patients had diagnosed ischaemic heart disease with a significantly higher proportion in the statin group (approximately 60%). About 20% of all patients had congestive heart failure. Adjusted mortality was lower in statin users than non-users in both subgroups and most of the other comorbidity subgroups. No effect modification on statins by ischaemic heart disease or congestive heart failure was shown.

Statin treatment

Information on statin treatment including type of statin, dosage, treatment duration and adherence to treatment was very variable. Three of the observational studies gave details on the types of statins used. In the study by Keddissi et al.²⁶ approximately 80% of statin users received simvastatin, and the remainder received lovastatin, atorvastatin and fluvastatin. In the study by Blamoun et al.²⁷ atorvastatin was the most common statin used (52%), followed by simvastatin (24%), lovastatin (10%), pravastatin (8%) and fluvastatin (6%). A third cohort study stated that statins included fluvastatin, simvastatin, pravastatin, atorvastatin, and rosuvastatin with no information on the distribution.²¹ The Japanese population-based analysis stated that during the study period pravastatin, simvastatin, atorvastatin, and fluvastatin were commercially available in Japan, but no information on relative prevalence of use was provided.²³ The study by Frost et al which included all drugs in the statin class was one of two retrospective studies to include information about the dose of statins used.²⁰ The usual minimum prescribed dose was found to be 10 mg/d. Statin exposure to any statin was classified into low daily dose (<4 mg/d) and moderate daily dose (≥ 4 mg/d) for any type of statin, averaged over a three month to one year period. The fact that the cut off between low and moderate daily dose lay below the minimum

prescribed dose indicated poor compliance. This study suggested a dose-dependent variation of response. The Dutch cohort study used a more sophisticated dosage classification.²¹ The dosage of statin therapy was converted to no dose, low dose (<25%), and intensified dose ($\geq 25\%$) of the maximum recommended therapeutic dose. Low dose statin treatment had no beneficial effect on short-term mortality in COPD patients. However, an intensified dose was associated with improved short-term survival. Both low-dose and intensive statin therapy were associated with improved long-term survival in patients with COPD. In the RCT the treatment group received pravastatin 40 mg daily over 6 months.¹⁹ In the retrospective studies duration of treatment varied from at least one prescription in the 60 days prior to the index date²⁵ to at least 90 days of cumulative statin exposure prior to death or withdrawal.²⁰ Any FDA approved statins had to be used for at least 3 months prior the last pulmonary function test in the study by Keddissi et al.²⁶ This study described a trend towards an association between the change in FEV1 and FEV and the duration of treatment with statins, but this did not reach statistical significance.

Discussion

The aim of this review was to evaluate evidence of beneficial effects of statin treatment in patients with COPD to determine implications for future studies. We assessed current evidence that statins may alter the natural course of COPD. We identified several observational studies that suggest a benefit of statin treatment on various clinically-relevant endpoints including all-cause mortality, deaths from COPD, respiratory-related urgent care, COPD exacerbations, intubations for exacerbations of COPD and lung function decline in COPD patients. There is evidence from one randomized controlled trial that exercise capacity is increased and dyspnea after exercise is decreased in COPD patients treated with statins.

There are certain limitations with the present systematic review. We deliberately did not use stringent selection criteria as we were aware that current evidence from research in this area is sparse. This resulted in heterogeneity across the selected studies with respect to study design, target population (different definitions for COPD), interventions (statin types, dosage, duration of treatment) and outcomes assessed. We did not include non-English-language papers, thereby possibly limiting the scope of included studies. As in any systematic review, publication bias was a concern, possibly leading to overestimation of the associations of statin treatment with favourable outcomes in COPD.

One important question, which is a matter of ongoing debate, is whether statins exhibit a beneficial effect in COPD because they affect cardiovascular comorbidities as opposed to having a direct disease-modifying effect on COPD. Søyseth et al. hypothesized that statins might improve all-cause mortality in COPD because many COPD patients probably have unrecognized ischaemic heart disease.²² Cardiovascular disease is increased in COPD patients due to various shared risk factors (eg, smoking, obesity, diabetes), and there also seems to be a possible synergy between cardiovascular events and pulmonary inflammation.²⁸ The inflammation that is associated with atherosclerosis and atherothrombosis may be worsened by the systemic inflammatory component of COPD. Studies that have examined the effects of air pollution have previously suggested an association between airways inflammation and cardiovascular events.^{29,30} However, the finding by Keddissi et al. that use

of statins was associated with an attenuated decline in lung function and a lower incidence of respiratory-related ED-visits and/or hospitalizations in patients with obstructive lung disease implies that statins may have a direct disease-modifying effect on COPD.²⁶

It is assumed that the observed benefits of statins in patients with COPD derive at least partially from the drugs' anti-inflammatory properties. However, none of the analysed retrospective studies that assessed the effect of statins on outcomes in COPD has examined the correlation between change in inflammatory markers and those outcomes. In their RCT Lee et al. found that pravastatin caused a significant mean decrease in hs-CRP over the course of the study, but about a fifth of patients actually had an increase in hs-CRP. As expected, they found evidence of a floor effect. That is, those with higher baseline CRP levels (>3mg/L) had a significant decrease in hs-CRP after statin treatment, whereas no changes in hs-CRP was observed in patients with low baseline CRP levels (<3 mg/L).¹⁹ In this study, significant improvement in exercise capacity in the statin treatment group correlated with decreasing CRP levels. However, no effect of pravastatin on lung function decline was found. The lack of effect on lung function in this RCT contrasts with observed inverse relationship between CRP and lung function in cross-sectional studies.^{31,32,33} It is possible that the study period of 6 months was too short to reveal a significant effect of statins on lung function in this trial.

There are data to show that CRP levels are a predictor of COPD morbidity and mortality,³⁴ and statins have been shown to reduce serum levels of CRP.³⁵ COPD patients with high baseline CRP levels (in a stable condition) could therefore be a subgroup to benefit most from statin treatment not just in regard to attenuated lung function decline, but also improved mortality. The recently published JUPITER study showed that rosuvastatin significantly reduced the incidence of major cardiovascular events in apparently healthy persons without hyperlipidemia but with elevated CRP levels.³⁶ However, besides the anti-inflammatory action, other possible effects of statins, eg anti-oxidant action, may be partially responsible for the apparent beneficial effect in COPD patients.

Current evidence is insufficient to determine whether smoking status influences the beneficial effects of statin therapy. Yet interestingly, present data, including the study by Alexeeff et al.,¹⁶ suggest that statins exhibit beneficial effects in current smokers as well as those who are not currently smoking.

Different statins could possess different modes of action, with resulting variations in outcomes. The lack of information on the effects of specific statins in most of the reviewed observational studies precludes further detailed analysis. Kiener et al. showed that the differential actions of statins are, in part, related to their lipophilicity. Lipophilic statins such as simvastatin and atorvastatin have the greatest anti-inflammatory potential.³⁷ No difference in FVC or FEV1 decline was seen between the different statins in the study by Keddissi et al where 80% of patients received simvastatin, and the other patients received either lovastatin, atorvastatin or fluvastatin.²⁶ However, all those statins are lipophilic, whereas pravastatin, which was used in the RCT by Lee et al.¹⁹ is hydrophilic. This might be a reason for the different effects of statin treatment on lung function decline in those two studies.

The relation of duration and dose of statin therapy to clinical outcomes in COPD or anti-inflammatory effects is unclear. A study of 107 hypercholesterolemic patients treated with simvastatin for 6 weeks showed a significant decline in cytokine levels; however, greater reductions were observed after 6 months.³⁸ Keddissi et al. described a trend towards an association between the change in FEV1 and FEV and the duration of treatment with statins, but this did not reach statistical significance. Although one of the studies demonstrated a dose-dependent gradient in response,²⁰ the precise dose dependency of effect remains unclear. Also, because statin therapy compliance is thought to be poor,³⁹ assessment of adherence to treatment (eg by measuring lipid profiles) is essential in statin studies.

Conclusions

In summary, our review shows that treatment with statins may have beneficial effects in patients with COPD, possibly reducing all-cause mortality, deaths from COPD, respiratory-related urgent care, COPD exacerbations, intubations for exacerbations of COPD and lung function decline and improving exercise capacity. While statins seem to influence systemic inflammation and cardiovascular morbidity in COPD patients, it appears likely that they also directly target airways inflammation. Types of statins, dosage and treatment duration necessary to exhibit a pleiotropic effect remain unclear. Most of the available data are based on observational studies and randomized controlled trials are urgently needed to evaluate the therapeutic effect of statins in COPD.

References

- 1 Murray CL: Alternative visions of the future: projecting mortality and disability. In *The Global Burden of Disease*. Edited by Murray CJL, Lopez AD. Harvard: Harvard University Press, 1996: 361-375.
- 2 Anthonisen NR, Skeans MA, Wise RA, Manfreda J, Kanner RE, Connett JE; Lung Health Study Research Group: The effects of a smoking cessation intervention on 14.5-year mortality: a randomized clinical trial. *Ann Intern Med* 2005, 142:233-239.
- 3 Medical Research Council Working Party: Long term domiciliary oxygen therapy in chronic hypoxic cor pulmonale complicating chronic bronchitis and emphysema. *Lancet* 1981, 1:681-686.
- 4 Nocturnal Oxygen Therapy Trial Group: Continuous or nocturnal oxygen therapy in hypoxemic chronic obstructive lung disease: a clinical trial. *Ann Intern Med* 1980, 93:391-398.
- 5 Smith SC Jr, Allen J, Blair SN, Bonow RO, Brass LM, Fonarow GC, Grundy SM, Hiratzka L, Jones D, Krumholz HM, Mosca L, Pasternak RC, Pearson T, Pfeffer MA, Taubert KA; AHA/ACC; National Heart, Lung, and Blood Institute: AHA/ACC guidelines for secondary prevention for patients with coronary and other atherosclerotic vascular disease: 2006 update: endorsed by the National Heart, Lung, and Blood Institute. *Circulation* 2006, 113:2363-2372.
- 6 Barnes PJ, Shapiro SD, Pauwels RA: Chronic obstructive pulmonary disease: molecular and cellular mechanisms. *Eur Respir J* 2003, 22:672-688.
- 7 Gan WQ, Man SF, Senthilselvan A, Sin DD: Association between chronic obstructive pulmonary disease and systemic inflammation: a systematic review and a meta-analysis. *Thorax* 2004, 59:574-580.
- 8 Lee JH, Lee DS, Kim EK, Choe KH, Oh YM, Shim TS, Kim SE, Lee YS, Lee SD: Simvastatin inhibits cigarette smoking-induced emphysema and pulmonary hypertension in rat lungs.

- Am J Respir Crit Care Med 2005, 172:987-993.
- 9 Palinski W: New evidence for beneficial effects of statins unrelated to lipid lowering. *Arterioscler Thromb Vasc Biol* 2001, 21:3-5.
 - 10 Davignon J, Leiter LA: Ongoing clinical trials of the pleiotropic effects of statins. *Vasc Health Risk Manag* 2005, 1:29-40.
 - 11 Bonetti PO, Lerman LO, Napoli C, Lerman A: Statin effects beyond lipid lowering: are they clinically relevant? *Eur Heart J* 2003, 24:225-248.
 - 12 Almog Y, Shefer A, Novack V, Maimon N, Barski L, Eizinger M, Friger M, Zeller L, Danon A: Prior statin therapy is associated with a decreased rate of severe sepsis. *Circulation* 2004, 110:880-885.
 - 13 Mortensen EM, Restrepo MI, Anzueto A, Pugh J: The effect of prior statin use on 30-day mortality for patients hospitalized with community-acquired pneumonia. *Respir Res* 2005, 6:82.
 - 14 Lundh A, Gøtzsche PC: Recommendations by Cochrane Review Groups for assessment of the risk of bias in studies. *BMC Med Res Methodol* 2008, 8: 22.
 - 15 Vandembroucke JP, von Elm E, Altman DG, Gøtzsche PC, Mulrow CD, Pocock SJ, Poole C, Schlesselman JJ, Egger M; STROBE Initiative: Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): explanation and elaboration. *PLoS Med* 2007, 4:e297.
 - 16 Alexeeff SE, Litonjua AA, Sparrow D, Vokonas PS, Schwartz J: Statin use reduces decline in lung function: VA Normative Aging Study. *Am J Respir Crit Care Med* 2007, 176:742-747.
 - 17 Menzies D, Nair A, Meldrum KT, Fleming D, Barnes M, Lipworth BJ: Simvastatin does not exhibit therapeutic anti-inflammatory effects in asthma. *J Allergy and Clin Immunol* 2007, 119:328-335.
 - 18 Johnson BA, Iacono AT, Zeevi A, McCurry KR, Duncan SR: Statin use is associated with improved function and survival of lung allografts. *Am J Respir Crit Care Med* 2003, 167:1271-1278.
 - 19 Lee TM, Lin MS, Chang NC: Usefulness of C-reactive protein and interleukin-6 as predictors of outcomes in patients with chronic obstructive pulmonary disease receiving pravastatin. *Am J Cardiol* 2008, 101:530-535.
 - 20 Frost FJ, Petersen H, Tollestrup K, Skipper B: Influenza and COPD mortality protection as pleiotropic, dose-dependent effects of statins. *Chest* 2007, 131:1006-1012.
 - 21 van Gestel YR, Hoeks SE, Sin DD, Simsek C, Welten GM, Schouten O, Stam H, Mertens FW, van Domburg RT, Poldermans D. Effect of statin therapy on mortality in patients with peripheral arterial disease and comparison of those with versus without associated chronic obstructive pulmonary disease. *Am J Cardiol*. 2008, 102:192-196.
 - 22 Søyseth V, Brekke PH, Smith P, Omland T: Statin use is associated with reduced mortality in COPD. *Eur Respir J* 2007, 29:279-283.
 - 23 Ishida W, Kajiwara T, Ishii M, Fujiwara F, Taneichi H, Takebe N, Takahashi K, Kaneko Y, Segawa I, Inoue H, Satoh J: Decrease in mortality rate of chronic obstructive pulmonary disease (COPD) with statin use: a population-based analysis in Japan. *Tohoku J Exp Med* 2007, 212:265-273.
 - 24 Global Initiative for Chronic Obstructive Lung Disease: Global Strategy for the Diagnosis, Management and Prevention of Chronic Obstructive Pulmonary Disease. NHLBI/WHO workshop report. National Heart, Lung and Blood Institute, Bethesda, 2001; NIH Publication No 2701: 1-100.
 - 25 Mancini GB, Etminan M, Zhang B, Levesque LE, FitzGerald JM, Brophy JM: Reduction of morbidity and mortality by statins, angiotensin-converting enzyme inhibitors, and angiotensin receptor blockers in patients with chronic obstructive pulmonary disease. *J Am Coll Cardiol* 2006, 47:2554-2560.
 - 26 Keddissi JI, Younis WG, Chbeir EA, Daher NN, Dernaika TA, Kinasevitz GT: The use of statins and lung function in current and former smokers. *Chest* 2007, 132:1764-1771.
 - 27 Blamoun AI, Batty GN, DeBari VA, Rashid AO, Sheikh M, Khan MA: Statins may reduce episodes of exacerbation and the requirement for intubation in patients with COPD: evidence from a retrospective cohort study. *Int J Clin Pract* 2008, 62:1373-1378.
 - 28 Sin DD, Man SF: Why are patients with chronic obstructive pulmonary disease at increased risk of cardiovascular diseases? The potential role of systemic inflammation in chronic obstructive pulmonary disease. *Circulation* 2003, 107:1514-1519.
 - 29 Peters A, Dockery DW, Muller JE, Mittleman MA: Increased particulate air pollution and the triggering of myocardial infarction. *Circulation* 2001, 103:2810-2815.
 - 30 Suwa T, Hogg JC, Quinlan KB, Ohgami A, Vincent R, van Eeden SF: Particulate air pollution induces progression of atherosclerosis. *J Am Coll Cardiol* 2002, 39:935-942.
 - 31 Aronson D, Roterman I, Yigla M, Kerner A, Avizohar O, Sella R, Bartha P, Levy Y, Markiewicz W: Inverse association between pulmonary function and C-reactive protein in apparently healthy subjects. *Am J Respir Crit Care Med* 2006, 174:626-632.
 - 32 Fogarty AW, Jones S, Britton JR, Lewis SA, McKeever TM: Systemic inflammation and decline in lung function in a general population: a prospective study. *Thorax* 2007, 62:515-520.
 - 33 Shaaban R, Kony S, Driss F, Leynaert B, Soussan D, Pin I, Neukirch F, Zureik M: Change in C-reactive protein levels and FEV1 decline: a longitudinal population-based study. *Respir Med* 2006, 100:2112-2120.
 - 34 Dahl M, Vestbo J, Lange P, Bojesen SE, Tybjaerg-Hansen A, Nordestgaard BG: C-reactive protein as a predictor of prognosis in chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2007, 175:250-255.
 - 35 Prasad K: C-reactive protein (CRP)-lowering agents. *Cardiovasc Drug Rev* 2006, 24:33-50.
 - 36 Ridker PM, Danielson E, Fonseca FA, Genest J, Gotto AM Jr, Kastelein JJ, Koenig W, Libby P, Lorenzatti AJ, MacFadyen JG, Nordestgaard BG, Shepherd J, Willerson JT, Glynn RJ; JUPITER Study Group: Rosuvastatin to prevent vascular events in men and women with elevated C-reactive protein. *N Engl J Med* 2008, 359:2195-2207.
 - 37 Kiener PA, Davis PM, Murray JL, Youssef S, Rankin BM, Kowala M: Stimulation of inflammatory responses in vitro by lipophilic HMG-CoA reductase inhibitors. *Int Immunopharmacol* 2001, 1:105-118.
 - 38 Rezaie-Majd A, Maca T, Bucek RA, Valent P, Müller MR, Husslein P, Kashanipour A, Minar E, Baghestanian M: Simvastatin reduces expression of cytokines interleukin-6, interleukin-8, and monocyte chemoattractant protein-1 in circulating monocytes from hypercholesterolemic patients. *Arterioscler Thromb Vasc Biol* 2002, 22:1194-1199.
 - 39 Wei L, Wang J, Thompson P, Wong S, Struthers AD, MacDonald TM: Adherence to statin treatment and readmission of patients after myocardial infarction: a six year follow up study. *Heart* 2002, 88:229-233.

Patterns of Perception Toward Influenza Pandemic Among the Front-Line Responsible Health Personnel in Southern Thailand

Tapanan Prateepko, Virasakdi Chongsuvivatwong

Thailand has joined the World Health Organization effort to prepare against a threat of an influenza pandemic. Regular monitoring on preparedness of health facilities and assessment on perception of the front-line responsible health personnel has never been done. This study aimed to document the patterns of perception of health personnel toward the threat of an influenza pandemic. Methods Q methodology was applied to a set of 385 health personnel in charge of influenza pandemic preparedness in the three southernmost provinces of Thailand. Subjects were asked to rank 33 statements about various issues of influenza pandemic according to a pre-designed score sheet having a quasi-normal distribution on a continuous 9-point bipolar scale ranging from -4 for strongly disagree to +4 for strongly agree. The Q factor analysis method was employed to identify patterns based on the similarity and dissimilarity among health personnel.

There were three main patterns of perception toward influenza pandemic with moderate correlation coefficients between patterns ranging from 0.37 to 0.55. Pattern I, health personnel, which we labeled pessimistic, perceived themselves as having a low self-efficacy. Pattern II, which we labeled optimistic, perceived the threat to be low severity and low vulnerability. Pattern III, which we labeled mixed, perceived low self-efficacy but low vulnerability. Across the three patterns, almost all the subjects had a high expectancy that execution of recommended measures can mitigate impacts of the threat of an influenza pandemic, particularly on multi-measures with high factor scores of 4 in all patterns. The most conflicting area was vulnerability on the possible impacts of an influenza pandemic, having factor scores of high (3), low (-4), and neutral (0) for patterns I, II, and III, respectively.

Strong consistent perceptions of response efficacy against an influenza pandemic may suggest a low priority to convince health personnel on the efficacy of the recommended measures. Lack of self-efficacy in certain sub-groups indicates the need for program managers to improve self-confidence of health personnel to participate in an emergency response.

The authors are with the Epidemiology Unit, Faculty of Medicine, Prince of Songkla University, Hatyai, Thailand. The authors wish to sincerely acknowledge all health personnel who participated in the study. Appreciative thanks to the Graduate School, PSU, and the Disease Control Department, Ministry of Public Health, Thailand for supporting the study. They also wish to thank Dr Alan Geater, Dr Vorasit Sornsrivichai, Edward McNeil, the Epidemiology Unit, Faculty of Medicine, PSU, and Darrell Beng, Adelaide, South Australia. Reprinted from BioMed Central Ltd, BMC Public Health. This is an Open Access article distributed under the terms of the Creative Commons Attribution License. This article has been edited for our readers. For the full text, go to BioMed Central and type in the full title.

An influenza pandemic is a significant natural health threat that has periodically occurred over the past 300 years. Its severe impacts to global human health, healthcare service, society, and economy were evidently documented during the previous pandemics. For a coming one, influenza experts have agreed that this threat is inevitable and possibly imminent. If the next pandemic occurs, it is expected that 20% of the global population will become ill, nearly 30 million will be hospitalized and a quarter of these would die within a few months of its attack. To mitigate the impacts of this threat, the World Health Organization has recommended that all countries should consider this threat as very important and urged them to make preparations a high national priority. Thailand occasionally has had serious outbreaks of avian influenza A (H5N1) since early 2004, in both poultry and humans. In response to these outbreaks and a possible future influenza pandemic, the national committee on avian influenza control and influenza pandemic preparedness has issued a national strategic plan for influenza pandemic preparedness. Beyond preparedness, the perception of each individual is also a fundamental factor that contributes to the spread, prevention, and control of infectious diseases. For example, during the SARS epidemics, the perceptions toward this disease had an effect on the preventive health behaviors (eg, hand hygiene, mask wearing) and that consequently contributed to containing the outbreaks. For a current threat of an influenza pandemic, sporadic perception surveys among health workers have been done in developed countries. Yet this issue has not been explored in developing countries, particularly in the southeast Asian region where it is more likely to be a source of the next pandemic. Southern Thailand experienced a probable SARS case in 2003, but there has been no reported case of avian influenza A (H5N1) in both poultry and human. However, the region faces a serious problem of ethnic violence. This unrest has led to the loss of over 2,600 lives and more than 7,000 injuries in the past 5 years. It is possible that the local health systems may have deteriorated due to the unrest leading to loosening of preparedness against the threat of an influenza pandemic. We have therefore conducted a study to investigate the preparedness. The current report is confined to perceptions related to the threat of an influenza pandemic with the objective to document the patterns of perception of health personnel toward this threat in southern Thailand. As health personnel are key persons for influenza pandemic preparedness and control, it is hoped that understanding their patterns of perception will allow control programs to properly improve the training. It may also be useful for other developing countries where an influenza pandemic is a serious threat, but the personnel are not fully prepared.

Results

After consultation with an expert in instrument development,

33 statements were used in the study. Although some statements may resemble others, they measure different aspects or domains on an influenza pandemic. Of a total 385 health personnel, 271 (70%) persons completed the score sheet. There were no statistically significant differences between responders and non-responders in terms of gender, age, religion, educational level, total period of working, job classification, experience of getting training on influenza pandemic preparedness and perceived levels of knowledge about an influenza pandemic, public health measures against an influenza pandemic and impacts of an influenza pandemic. The basic characteristics of the 271 respondents are presented in Table 2. Ninety subjects were classified into factor I (in other words, the first pattern composites of 90 health personnel), 40 into factor II, and 62 into factor III. The other 79 subjects were not classified into any factor because all their loading values were less than 0.45 or had high loading on more than one factor. The three patterns had scores for each specific statement distributed into the Q-sort model or composite factor array. All three patterns of health personnel strongly perceived that multi-measures must be performed during an influenza pandemic. Statement 4 was the most dissenting issue with factor scores of 3, -4, and 0. Health personnel classified as pattern I quite strongly perceived that Thailand will have possibly high impacts from an influenza pandemic if and when one occurs, but those classified in pattern II strongly disagreed, and those in the remaining group were neutral. All three groups of health personnel have strong perception on response efficacy of the control measures rather than on the other domains. The left extremes of the three patterns, on the other hand, contain different mixtures for different patterns. Health personnel classified into pattern I were pessimistic. They had negative perceptions of self-efficacy. Health personnel classified into pattern III were less extreme about this. None of the dark gray cells are present in the left extreme regions of the pattern II, indicating optimism of the group of personnel. All groups had positive perceived response efficacy of the measures. Patterns I and III, however, perceived low self-efficacy, in contrast to high perceived self-efficacy of pattern II. Table 3.

Optimistic personality of pattern II was also expressed as perception of low severity and low vulnerability, where the pattern I has isolated neutral perception of severity with a moderate level of perceived vulnerability. Finally, more mixed appraisal is found in pattern III, the group who perceived a low level of vulnerability but a very high level of severity.

We identified three main patterns of health personnel in southern Thailand based on the perception toward a threat of an influenza pandemic. Pattern I was pessimistic (strongly perceived response efficacy, but perceived low self-efficacy). Pattern II was optimistic (strongly perceived response efficacy, but perceived low severity and low vulnerability). Pattern III was mixed (strongly perceived response efficacy, but perceived low vulnerability and low self-efficacy). A high perception on response efficacy was predominantly found in all health personnel groups. Perceptions on vulnerability were more varied. The majority of our health personnel perceived low self-efficacy toward an influenza pandemic. Self-efficacy is one important component of coping appraisal of the PMT. It has powerful influence on human's feeling, thinking, motivation, and behavior. Previous meta-analyses provided evidence for self-efficacy having the largest effect size and was the strongest predictions of protection motivation. People with low self-

efficacy usually believe that tasks are harder than they can handle. This can lead to limit task planning, increase stress, reduce the low level of attempt, and having a tendency to avoid duties and activities. Balicer et al reported that nearly a half of local health workers may be unwilling to report to duty during a pandemic event. However, that study did not identify different patterns of health workers as our study has done. Another conventional survey conducted among a general population (rather than health workers) in developed countries of Europe and Asia on avian influenza risk perception showed a similar result. The level of self-efficacy among the respondents was also low and the authors concluded that a low level of self efficacy may obstruct any interventions. The most dissenting issue among our health personnel toward this threat was on vulnerability of possible impacts in the country. Naturally, the occurrence and severity of an influenza pandemic cannot be predicted. Fifteen per cent of our health personnel perceived the threat to have low severity and low vulnerability. In other words, this group of health personnel was optimistic that such a threat would not severely affect people's lives. Perception of low level of severity and vulnerability or low levels of appraised threat of an influenza pandemic may inhibit motivation of health personnel to engage in protective behavior. However, the effect sizes of such two components in previous meta-analyses were small to medium and barely predicted of protection motivation and behavior compared to the components of coping appraisal (response efficacy and self-efficacy). Perception of response efficacy was stronger than other domains. This may be influenced by past experiences of the country, which after employing on multi-sectors and multi-measures could successfully suppress avian influenza A(H5N1). This study used a wide range of front-line health personnel responsible for influenza pandemic preparedness. Thus, it may reflect the problems specific to this area with acceptable accuracy. The study was confined to the three southernmost provinces of Thailand where avian influenza A (H5N1) has never occurred. Our study subjects might be different from those in other regions of the country where the infected cases of that avian influenza in both humans and poultry have been reported, and intensive avian influenza controls have been fully activated. The study subjects were also predominated by personnel from health centers and community hospitals in rural areas. The threat of a pandemic may be less compared to in urban areas. The study was based on Q methodology, which had never been employed among local health workers; thus, the data have to be interpreted with caution. Approximately 30% of the respondents were not able to be classified into any of the three groups determined by our factor analysis.

Despite the above limitations, this study highlights important findings. Strong consistent perceptions of implementing recommended measures against an influenza pandemic can remove or mitigate impacts of this threat, and may suggest a low priority to convince health personnel on the efficacy of the measures. Perception of low self-efficacy in certain subgroups who gave low scores on the statements related to self-efficacy on an influenza pandemic indicates the need to improve self-confidence of health personnel to participate in an emergency response by the control program.

A Trial of the ASV Mode Using the Hamilton G5 Ventilator in NICU

Heloisa Georgiev, RRT-NPS

Our NICU at Florida Hospital for Children in Orlando, trialed the Hamilton G5 ventilators back in May 2009. Infants who weighed between 760 grams and 6.8 kilos were placed on different modes such as APV/CMV, APV/SIMV and ASV. Out of all the patients who were placed on the ventilator, the one that definitely stood out the most was baby "A" who had been in our NICU for six months and weighed 6.8 kilos.

At that time baby "A" was being ventilated via the Babylog 8,000+ Draeger infant ventilator on Assist/Control mode with peak inspiratory pressures as high as 42 cmH₂O.

Taking into consideration that the patient weighed over 3 kilos, and his increased work of breathing on the assist/control mode, the decision was made to place him on the ASV mode (adaptive pressure ventilation) via the Hamilton G5. The staff had utilized the mode in the pediatric unit and felt very comfortable managing the patient.

Prior to making the switch, the patient's minute volumes on the assist/control mode were carefully noted and recorded. The goal was to set a target percent minute volume that was similar to what the patient was generating before. Initial settings were: 100% target minute volume, PEEP +7 and 21% FiO₂.



Due to an initial increase in respiratory rate and patient generated (actual) minute volume, the percent minute volume was increased from 100% to 130% in an attempt to mimic his actual minute volume and provide the support demanded.

His respiratory rate decreased considerably fast after this change and he appeared to be a lot more comfortable. Peak inspiratory pressures continued to be in the high 30s cmH₂O range and tidal volume mid 30s to mid 40s mls.

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A capillary blood gas obtained an hour after placing him on the ASV mode. Results were: pH 7.56, PCO₂ 35, PO₂ 67, HCO₃ 31 and base excess +8. At that point the percent VE was weaned back to 100%, which translated in a target VE of 1.7 ml (very close to the previous amount on Babylog 8000+ Draeger ventilator).

Baby "A" dictated how he wanted to be ventilated, switching back and forth between breathing spontaneously with the aid of pressure support or receiving full controlled breaths from the ventilator. His respiratory rate remained stable in the mid 30s–40s whenever breathing spontaneously. There was a remarkable decrease in his work of breathing.



Another capillary blood gas was drawn 3 hours after being on the ASV mode at 100% VE which revealed pH 7.44, PCO₂ 44, PO₂ 48, HCO₃ 30 and base excess +5, the best capillary blood gas result the patient had had in days.

PIPs had decreased significantly to mid 20s without compromising the delivery of volume.

Baby "A" continued on the ASV mode for over 36 hours. Every capillary blood gas obtained during that time was within normal limits. He appeared very comfortable on the ASV mode. When the trial time was over, it was a difficult task to take him off the ASV mode and place him back on his previous ventilator/ settings.

The NICU staff was very pleased with the result they witnessed. Ventilating large infants in our NICU can be challenging at times. In utilizing the ASV mode, the infant was able to dictate how he wanted to be ventilated and it made weaning completely up to the patient. Pressure support was automatically adjusted as the patient's lung compliance and resistance improved.



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