Perinatal-Pediatrics Bulletin

Sept./Oct. '99

American Association for Respiratory Care

Notes from the Chair

by Peter Betit, RRT

In preparing the last few *Bulletins*, I have solicited the assistance of colleagues from around the country to act as guest editors. I feel that it is important to draw upon the experiences of others in order to provide the section membership with a well-balanced *Bulletin* and to gain a better understanding of the current issues and innovations facing other centers. I would like to express my thanks for the efforts and contributions made by these guest editors. They are — Doug Petsinger, BS, RRT, from Egelston Children's Hospital in Atlanta; Jenni Raake, BS, RRT, from Children's Medical Center in Cincinnati; and in this issue, Theresa Schultz, BA, RRT, from Children's Hospital of Philadelphia. Please contact me if you would like to spotlight your department and institution by acting as guest editor.

The final revisions of our section's Resource Panel are near completion and will be published in conjunction with a future *Bulletin*. I will soon be calling on the members of this Panel to participate in several section activities, including reviewing CPGs, preparing items for this *Bulletin*, and submitting topics for the AARC International Respiratory Congress to be held in October of 2000.

Speaking of next year's meeting, since it is being held earlier than usual, program topics will need to be submitted earlier. I hope that you will assist me in this endeavor by contacting me with any suggestions for topics that you would like to see presented, along with recommendations for speakers.

We also have an opportunity to present the five most important and pressing issues facing perinatal-pediatric respiratory therapists to the AARC Program Committee. Again, I ask for your assistance. What are the most urgent needs facing RTs in your area? You can send your thoughts to me via the contact information that appears on page two. ■

Op Ed: *Alphabet Soup*

by Peter Betit, RRT

The NBRC and AARC have not sanctioned the use of an acronym for RTs who have successfully passed the Perinatal/Pediatric Specialty exam, nor has there been a federal trademark established for such an acronym. Nonetheless, the acronym "P/P Spec," or versions thereof, seems to be cropping up in correspondences, articles, and scientific papers.

How many letters does one need after his or her name? Additional letters do not necessarily distinguish the skill level of one therapist from another. I am certain there are very talented RTs working in the perinatal/pediatric setting who have not taken the specialty exam. Successful completion of the exam does identify you as a specialist and is certainly a feather in your cap, but another acronym is simply not needed. Physicians take numerous exams in order to satisfy various certification requirements, but they are typically designated only as MDs. Respiratory therapists are generally licensed by their respective states. Most states utilize the NBRC certification and registry exams to approve licenses for RTs. Is it not enough to simply be a CRTor RRT?

Before you answer that question, consider the alternative: Jane Doe, BS, CRT, RRT, RCP, RPFT, P/P Spec. Please, let us avoid the alphabet soup. ■

AARC Cultural Diversity Forum

5-7 p.m.
December 13, 1999
Las Vegas Hilton

Contact AARC Cultural Diversity Committee Chair Janyth Bolden at jbolden@chw.edu for more information.

Notes from the Guest Editor: *Research in Respiratory Care*

by Theresa Ryan Schultz, BA, RRT, Children's Hospital of Philadelphia

In addition to caring for patients with cardiopulmonary disease, respiratory therapists are sometimes called upon to investigate alternatives to care and recommend therapies. From time to time, the quest for alternatives and "best fit" solutions leaves us with more questions than answers.

Research in our respiratory care department started with a question and has developed into a concurrent discipline. Our first formal hypothesis was formulated from this question: "Does airway pressure release ventilation ventilate and oxygenate pediatric patients with lower peak inflating pressures than conventional ventilation?" In order to objectively answer this question, we formulated a formal proposal and submitted it to our Internal Review Board (IRB). In doing so, we learned that there are many aspects of research that deserve consideration.

Planning phase

After the respiratory care team develops the research question, it must decide how it could be best answered (bench trial, clinical trial, or pure science lab study). From there, the team should write an IRB proposal and develop a plan for implementation. The IRB proposal must include:

- aim of the study (hypothesis)
- background of the project (what makes you want to pursue this question)
- identification of what subjects will be studied and what subjects will not be studied (inclusion and exclusion criteria)
- procedures that will affect the subject
- research design and method
- statistical analysis
- sample size considerations
- personnel needed for the study to function
- financial considerations
- potential risks
- potential benefits
- risk/benefit analysis
- protection of subjects and consent

Data collection

Data collection is simply the documentation of patient response to intervention or lack of intervention. Monitoring your patient's cardiopulmonary status, measuring described variables in a bench or lab setting, or interviewing a patient or family are forms of data collection. While developing your data collection tool, it is crucial to include data which are most closely related to the research question.

Data analysis

Data abstraction, entry, and analysis constitute the climax of the research project. This process should occur after the first few patients have been enrolled so that you can identify any missing links, and then should occur periodically after that. Once the data are appropriately analyzed, conclusions can be made.

Publication

The natural progression of the discipline of research in respiratory care is publication of the work; first in abstract, then in manuscript form.

Something for everyone

All phases of research can involve respiratory care. Every practitioner in our department participates in research. In some cases, therapists are used exclusively for patient enrollment. Ninety-eight percent of enrollment attempts in an asthma study conducted in our Emergency Department, for example, were successfully realized because the entry criteria included children over the age of two with wheezing who were receiving nebulized beta agonist administered by the therapist.

Data collection for all of our studies is done by the unit-based respiratory therapist. Current ICU and OR studies include:

- Nitric oxide in ARDS
- Nitric oxide in pulmonary hypertension
- Exogenous surfactant replacement in ARDS
- Evaluation of ventilator weaning protocols in pediatrics
- Evaluation of sedation in pediatric patients requiring mechanical ventilation
- Evaluation of tape versus tube stabilizer to secure endotracheal tubes
- Evaluation of kinetic and percussive therapies available on the PediDyne Crib
- Evaluation of alternate gases for patients with single ventricle physiology
- Evaluation of airway pressure release ventilation
- Resting energy expenditure in mechanically ventilated pediatric patients
- Short-term outcomes of pediatric patients with asthma

All of these studies involve practice issues of the respiratory therapist, which is why it only makes sense for them to formally conduct the research.

Clinical Respiratory Research Specialist

In addition to in-patient data collection, a group of therapists in our department conducts follow-up surveys on the physical and functional capabilities of our asthmatic patients after discharge. This occurs largely by telephone and to some degree via home visits from a respiratory therapist.

Afew therapists in our department participate in data abstraction, entry, and analysis with the guidance of statistical consult. Several of our therapists have authored abstracts. Our first manuscript is under review.

We have been fortunate enough to streamline the disciplines of research and

"Notes" continued on page 3

Perinatal-Pediatrics Bulletin
is published by the
American Association for Respiratory Care
11030 Ables Lane
Dallas, TX 75229-4593
(972) 243-2272
FAX (972) 484-2720
e-mail: info@aarc.org

Kelli Hagen
AARC communications coordinator

Debbie Bunch
Bulletin managing editor

Edwards Printing
Bulletin typesetting

Section Chair and Bulletin Editor
Peter Betit, RRT
Children's Hospital
300 Longwood Avenue
Boston, MA 02118
(617) 355-6118
FAX (617) 738-0338
e-mail: betit@a1.tch.harvard.edu

Medical Advisor
Mark Wilson, MD (ACAI)
(402) 390-5624
FAX (402) 354-5746
email: mwilson@childrens_omaha.com

Consultant Panel
Mike Czervinske, RRT
University of Kansas Medical Center
Department of Respiratory Care Education
3901 Rainbow Blvd.
Kansas City, KS 66106-7606
(913) 588-4631
FAX (913) 588-4631
email: mczervin@kumc.edu

"Notes" continued from page 2

respiratory care into a Clinical Respiratory Research Specialist position. This was made possible by external funding when the short-term outcomes in pediatric asthma project called for a research coordinator who could devote time and attention to start up and follow-through with all aspects of the study. Once this position was put in place, new proposals were written and external funding continued. Today the Clinical Respiratory Research Specialist is involved in proposal writing, related staff education, grant proposal writing, and managing the time and finances of clinical research studies. It is more than a full-time job.

So as you can see, what started out as a question about current practice in respiratory care has developed into a full-scale concurrent discipline of research and respiratory care.

Professional growth prevails

There are many unanswered questions in our practice, and what we learn from the pursuit of their answers will lead to practice changes based on clearly defined objectives. Our ultimate goal is to objectively answer questions about respiratory care so that we may promote professionalism and develop evidence-based standards of care for determining best practice. Professional growth prevails. ■

Education Plays an Important Role in Asthma Management

by Angela D. Hedgman, RRT, Children's Hospital of Philadelphia

Asthma is one of the most common and costly diseases in the United States. It is a chronic disease that affects 4.8 million children per year, according to the Centers for Disease Control and Prevention (CDC). Despite significant advances in the diagnosis and treatment of this illness, the health burden in the United States is increasing rapidly. Turn on the television and you see commercials geared to asthma management programs. Athletes are speaking out about asthma and how you can manage your symptoms and still enjoy an active lifestyle.

In response to this situation, we have developed a plan of care for our patients that includes components from the *Guidelines for the Diagnosis and Management of Asthma*, published by the National Heart, Lung and Blood Institute (NHLBI). We recognize the importance of teaching our patients and their families about asthma and how to control asthma symptoms. This process starts as soon as the patient enters the emergency department and continues throughout his or her hospital stay.

Our Asthma Care Unit (ACU) utilizes a multidisciplinary team of respiratory therapists and nurses to treat and educate the patients and their families. Realizing that self-management is an important factor in maintaining this disease, our focus is on education. We appreciate that people have various learning styles and provide both written and visual education tools. There are classes offered for individuals as well as small groups. We encourage families to learn together and include siblings, extended family, and friends.

We also refer patients and their families to community asthma programs. These programs are conveniently located in local churches, schools, and health centers. They provide a resource for families in a familiar environment. Many times parents pick up more things from shared experiences than they do from traditional instruction. They get to talk about problems and solutions pertaining to many issues regarding the care of a child with a chronic disease and how it impacts the family. The children are taken into a separate room and receive education geared to their level of understanding. They play games and watch videos based on asthma management. They get to practice taking a metered dose inhaler and learn how to use a peak flow meter. They also learn how to keep a diary.

The best way to manage an asthma attack is to prevent it. Communication and education is the key to successful management. The role of the health care provider is to facilitate this education process. ■

Data Management or Management with Data?

by Patricia A. Achuff, MBA, RRT, Children's Hospital of Philadelphia

Data are pieces of information organized for analysis or decision-making. Sometimes during data collection, information is gathered that can be useful in ways other than originally intended. In some cases, this new information can be used to make more informed management decisions.

Over the past year, the respiratory care department at The Children's Hospital of Philadelphia has been conducting an Asthma Outcomes Research Study. Any patient over the age of two years who received a Ventolin treatment in the emergency room was eligible for enrollment in the study. Each patient was followed up at home via a phone call at one day and two week increments. The follow up information was used to determine patient compliance, as well as physical and functional assessment of the patient. The patient medical record was used to collect information on demographics, asthma severity, chronic medications, current medications, discharge medications, and acute emergency room/inpatient treatment. It was primarily my responsibility to abstract pertinent information from the patient medical record.

My involvement with the abstraction of data has brought new insights into how our staffing in the ER may need to be changed to provide better quality care to our asthmatic population. Specifically, I found that during our busiest times in the emergency room, some of the patient records were incomplete. The deficiencies were noted on the nursing record, physician record, and respiratory care record. Some medications were not signed out, and some of the Ventolin treatments were not recorded as pre- and post-assessment. We were not recording peak flows on many of the patients who could benefit from this form of monitoring, and there was a small time lag between when medications were ordered and when they were given.

Clearly, in order to try to keep up with the treatment demand, there was a lack of clear and concise documentation by all levels of personnel. While quality care was always being given to the patient, it became apparent that it might be necessary to change staffing patterns in the emergency room to provide more complete documentation and a better response time in patient treatment.

Through data abstraction, we found that many patients in our ER are discharged with metered dose inhalers and home nebulizers. During our busy times, we need to

"Data Management" continued on page 4

"Data Management" continued from page 3

question whether the appropriate teaching has been given to our families. We also need to realize that even when the parents are given the appropriate teaching, many of the families will not remember how to use the equipment. Indeed, we often wonder how many of these patients will ever use the equipment again. This leads us to wonder how many of these same children we will see back in the ER within the next few days. These repeat patients cause an increase in the already busy ER patient population. Clearly, we need to look at how we, as a respiratory care department, can help to decrease these repeat ER patients.

By doing one day and two week patient follow ups, we found that many of the children who seek medical attention in our ER do not follow up with a primary care physician. As a result, our respiratory care department has the responsibility to build patient and family teaching into the acute care setting. As part of family teaching, we need to help parents identify their child's asthma triggers and how to handle them. We also need to make sure families know what the appropriate treatment is and how often it should be given.

Parents need to be educated on how to decide when to bring their child directly to the ER and when to see their primary care physician. If the child does not have a primary doctor, the family should be informed that it is important to have one physician follow their child's asthma care. To help facilitate patient education, we need to make our physician network and other resources within our community and facility available to parents. As a result, they will identify us as patient care advocates, not just patient care providers.

So as you can see, our Asthma Outcomes Research Study not only answered questions, but also raised them. As managers, we should see this as a positive side effect of research because it increases our awareness of how we can manage our team to meet the increasing needs of our asthmatic patient population. ■

How to Assess and Maintain Competence in a Large, Multiskilled, Variably Confident Department

by Lorraine F. Hough, MEd, RRT, Children's Hospital of Philadelphia

The aim of our competency assessment program is to educate and evaluate the skills required to provide quality respiratory care to our patients. We identify areas of growth and development and provide opportunities for ongoing learning.

Competency assessment occurs on an annual basis through a collaborative process and is appraised throughout the employment of the therapist. The continuum includes an initial assessment at hire, proof of competency during orientation, and ongoing annual competency assessment.

Each new candidate's assessment includes the validation of his or her license and certification, along with verification of previous experience, current skills, and abilities through the interview process. We also check references, resumes, and applications.

During orientation, proof of competency covers core job responsibilities, frequently used and high-risk job accountabilities, and age-specific concepts. A learning style inventory and a pediatric multiple-choice exam are administered. Orientation runs from four to eight weeks, depending on the experience of the new employee.

Our ongoing competency assessment program occurs during our "slow" summer months. In general, this system relates to our hospital-wide performance improvement model, which uses data to determine processes needing improvement and methods and checks for improving them. The competencies are assigned through the collaboration of the shift supervisors, the education specialist, and the individual therapist. New or changing policies, procedures, technologies, problematic job aspects, and high-risk functions and accountabilities are considered, as are the confidence and skill level of each therapist.

We select skills from each of the three domains of skill (del Bueno, 1980): eight from the technical domain, two from the critical thinking domain, and two from the interpersonal domain. Each employee is responsible for completing his or her own competencies using verification methods he or she selects from an approved list for each competency. These options include return demonstrations in the clinical or lab setting, in-services or presentations for other members of the staff, case studies, exemplars, peer reviews, self assessments, discussion groups, mock surveys, and multiple-choice tests. No two therapists have exactly the same list, and each list is different from year to year.

Accountability for competency assessment occurs on three levels — the education specialist, the supervisor for each shift, and the employee. The education specialist is responsible for documenting and tracking the process, developing new competencies, and providing education and consultation on competency assessment. The supervisor of each shift is responsible for identifying specific areas of competency with staff involvement, creating an environment promoting timely assessment and ongoing growth and development, providing education about the process, and monitoring the employee's progress. The employee is responsible for completing his or her list of competencies, collecting evidence demonstrating skill, and participating in competency development. All participate in evaluating the competency program.

At the end of the competency period, the employee's successful completion of the process is assessed. The employee is deemed "competent" only when 100% of the indicated competencies for his or her job class are successfully completed. Otherwise, an action plan is initiated that includes revised indicators and alternatives.

This process will continue to evolve over time as new and challenging technologies are added to our arsenal of therapies. We consider this to be the best process for attaining our goals of educating and evaluating personnel skills while providing quality care to our patients. ■

Request For Assistance: *New Technology*

Susan Blonshine is writing a "clinical perspectives" article for AARC Times on new technologies in 1999 and would like to know what new technology this year has had the greatest impact on your specialty area and why.

Please respond by October 10 to Susan by email (sblonshine@aol.com) or fax (517-676-7018). ■

Alternative Airway Management

by Roberta L. Hales, BS, RRT, Children's Hospital of Philadelphia

What is an LMA? It is a Laryngeal Mask Airway used during elective and uncomplicated anesthesia cases instead of the traditional bag mask ventilation and endotracheal intubation.[1] The LMA has been available in the United States since 1992. It is available in different sizes to accommodate the neonatal to the large adult population.

The LMA is not a foolproof device for obtaining an airway. In the event that the airway is not placed correctly, there is an increased risk of regurgitation from the stomach. It is also contraindicated for patients with decreased pulmonary compliance secondary to the low-pressure cuff of the laryngeal mask. Use of the mask requires the lowest peak inflating pressure, usually 20 cm H_2O.

The LMA is incorporated into the American Society of Anesthesiologists' Difficult Airway Algorithm as an option and alternative for patients considered high risk/difficult airway management.[2] Now, with the availability of the smaller sizes for the neonatal and pediatric populations, the use of the LMA may be expanded outside the operating room to the intensive care and conscious sedation units. Caution is warranted because the technique for insertion of the LMA requires adequate sedation/anesthetic to prevent the patient from developing laryngeal spasm.

The LMA has opened many doors for anesthesiologists looking for an alternative to traditional airway management techniques. Currently, we have all sizes of LMAs available in our pediatric intensive care unit, as well as in our operating room complex, for pediatric patients who are identified as "high-risk/difficult airway."

References

1. Brain, A., Derman, W., Goudsouzian, N. Laryngeal Mask Airway 1996.
2. American Society of Anesthesiologists Task Force, Practice Guidelines for Management of the Difficult Airway. Anesthesiology, 1993; 78 (3): 597-602. ■

Size 1	neonates/infants up to 5 kg.	mask inflation volume: 4cc
Size 1.5	infants 5-10 kg.	mask inflation volume: 7cc
Size 2	infants/children 10-20 kg.	mask inflation volume: 10cc
Size 2.5	children 20-30 kg.	mask inflation volume 14cc
Size 3	children and small adults >30 kg.	mask inflation volume 20cc
Size 4	normal and large adults	mask inflation volume 30cc
Size 5	large adults	mask inflation volume 40cc

Medical Gas Administration in the ICU

by Suzanne M. Durning, BS, RRT, Children's Hospital of Philadelphia

In the intensive care units at the Children's Hospital of Philadelphia, we utilize a variety of inspired gases in conjunction with mechanical ventilation and oxygen delivery devices such as hoods or nasal cannulas.

Inspired carbon dioxide (CO_2) affects pulmonary vascular tone. Increased pulmonary vascular resistance with resultant pulmonary vasoconstriction limits pulmonary blood flow. This manipulation of the distribution of blood between the pulmonary and systemic circuits pumped from the heart provides adequate arterial oxygenation and systemic blood flow and minimizes the effort of the ventricular muscle. Patients with single ventricle physiology who are at risk for increased Qp/Qs sometimes require this intervention.

Technical application of inspired CO_2 is possible via mechanical ventilation or hood. At the Children's Hospital of Philadelphia, CO_2 is delivered through the Servo 900C for patients who are intubated, mechanically ventilated, and breathing spontaneously above the preset SIMV rate. The room air and CO_2 gases are blended and delivered to the bellows of the ventilator via the low pressure inlet on the Servo 900C. This blended gas is also delivered to the constant flow setup adapted to the Servo 900C. A steady state gas delivery to the patient for both mechanical and spontaneous breaths is achieved with this system.

CO_2 may also be delivered through the Servo 300 for patients who are mechanically ventilated and who are breathing in phase with the ventilator. Our research has shown that the measurement of CO_2 delivered varies as much as 10-11 mm torr with simulated spontaneous breathing via the Servo 300. This degree of variation may result in hemodynamic instability in this patient population.

Inspired CO_2 is measured with the Hewlett Packard CO_2 monitor on the CR monitor at the bedside or with the Nellcor CO_2 monitor. It is important to remember to set appropriate alarms for high and low inspired CO_2.

Possible side effects and adverse reactions to CO_2 delivery include: increased respiratory rate, acidosis, dyspnea, increased intracranial pressure, muscle tremors, changes in hemodynamic status, and nausea and vomiting.

Nitrogen dioxide (N_2) may also be used to limit pulmonary blood flow in patients with single ventricle deficit who are at risk for increased Qp/Qs. Alveolar hypoxemia created by the introduction of N_2 causes vasoconstriction and limits pulmonary blood flow. N_2 is titrated into the inspiratory limb of the ventilator circuit to achieve the prescribed FiO_2. FiO_2 of 15-20% is the range commonly ordered. N_2 may be delivered via hood to patients who breathe without the assistance of mechanical ventilation. The oxygen analyzer used in conjunction with N_2 is specially adapted with a low alarm of 15%.

Possible side effects and adverse reactions to N_2 therapy include severe hypoxemia and changes in the hemodynamic status.

Many questions remain unanswered regarding the long-term effects of CO_2 and N_2 delivery, including those regarding possible effects on other organs and systems.

Nitric oxide (NO) has been described as the "molecule of the century." The Nobel Prize has been awarded to Drs. Furchgott, Ignarro, and Murad for their discovery that

"Medical Gas" continued on page 6

"Medical Gas" continued from page 5

NO is a signaling molecule in the cardiovascular system. Clinical work with low levels of inspired NO found it to be a selective pulmonary vasodilator.[1] Inhaled NO stimulates endogenous guanylate cyclase, increasing cyclic guanidine monophosphate (cGMP). This results in a reduction of intracellular calcium, thereby decreasing vascular tone.[2] The pulmonary artery pressure is decreased without a corresponding decrease in systemic pressure because NO binds to hemoglobin and inactivates the vasodilator response to NO.

While the use of inhaled NO is still investigational, the patient populations studied for potential benefit from NO are expanding rapidly. Currently, the potential benefit from the application of inhaled NO is being studied in patients with PPHN, post CPB coronary/valvular repair, primary PHTN, ARDS, and sickle cell disease.

There are numerous systems available for the delivery of nitric oxide. The InoVent system by Ohmeda is both a delivery and analyzing system. Because of this feature, the set NO remains stable even with changes in a patient's minute ventilation. The InoVent measures NO, nitrogen dioxide (NO_2) and oxygen (O_2). NO_2 is formed when NO reacts with O_2. Levels of NO_2 (>3 ppm) have been shown to produce severe ARDS, alveolar cell hyperplasia, altered surfactant hysteresis, changes in the epithelium of the terminal bronchiole, and loss of cilia.[3] Methemoglobin formation occurs when NO binds to hemoglobin. Methemoglobin levels are measured daily in patients receiving NO. Since most of our patients receive low dose NO therapy, the potential risk for elevated NO_2 or methemoglobin levels is low. However, it is important for the clinician to closely monitor NO_2 and methemoglobin levels in any patient receiving NO therapy. The majority of our patients receiving NO therapy have required intubation and mechanical ventilation. We have also delivered NO and O_2 via hood, aerosol mask, and nasal cannula.

Environmental testing has been done at our institution to monitor the exposure of clinicians to NO and NO_2. This was done at the bedside of patients receiving NO via mechanical ventilation and patients receiving NO via aerosol mask. In both instances, the levels were < 0.5 ppm.

It is possible that potential side effects and adverse reactions have yet to be identified, since the use of inhaled NO is still investigational.

Helium-oxygen gas mixtures (heliox) have been used to manage airway obstruction. Because of its lower density, heliox gas therapy provides a less turbulent flow to the airways. Decreased resistance and increased laminar flow enable this very light gas to act as a carrier for oxygen. The Reynold's number is the ratio of kinetic and viscous forces affecting airflow. This predicts whether airflow in a tube will be laminar or turbulent.[4] Administration of a heliox gas mixture may significantly reduce the Reynold's number, thereby increasing laminar flow.

Heliox gas mixtures of 80/20, 70/30, or 60/40 may be delivered to patients requiring intubation and mechanical ventilation. Heliox may also be administered to patients who are spontaneously breathing via a small hood or tightly fitting face mask. These systems should be closely monitored to minimize the loss of the heliox gas mixture into the environment.

Possible side effects of heliox include hypoxemia secondary to the decrease in FiO_2 delivered, and temporary changes in the voice/cry of a patient.

Respiratory therapists at The Children's Hospital of Philadelphia are skilled in the delivery of medical gases via mechanical ventilation and oxygen delivery devices to spontaneously breathing patients. Close monitoring of patients receiving medical gases is imperative to ensure safe and effective treatment and to minimize potential side effects or adverse reactions to inspired gases.

References

1. Frostell C, Fratacci MD, Wain JC, Jones R, Zapol WM. Inhaled nitric oxide: a selective pulmonary vasodilator reversing hypoxic pulmonary vasoconstriction. Circulation 1991;83(6):2038-2047
2. Moncada S, Higgs, EA. Molecular mechanisms and therapeutic strategies related to nitric oxide (review). FASEB J. 1995;9(13):1319-1330
3. Stephens RJ, Freeman G, Evans MJ. Early response of lungs to low levels of nitrogen dioxide: light and electron microscopy. Arch Environ Health 1972;24(3): 160-179.
4. Altman PL, Dittmer DS, eds. In: Respiration and circulation: general principals. Bethesda: Federation of American Societies for Experimental Biology p1-10, 1983 ■

Practical Application of Volume Guarantee Ventilation with the Babylog 8000 Ventilator

by Sandra R. Wadlinger, BA, RRT, Children's Hospital of Philadelphia

Traditionally, the Babylog 8000 ventilator has been used as a constant flow, time-cycled, pressure-limited ventilator for neonates and small infants in our institution. Among the features of this machine are its ability to provide synchronized intermittent mandatory ventilation (SIMV) and accurate breath-to-breath tidal volume monitoring with a unique flow sensor positioned at the patient's endotracheal tube. The patient trigger is flow-based and is sensitive enough to detect minimal inspiratory effort in very low birth weight infants.

Our experience with this ventilator has been very positive. Its accurate measurement of breath-to-breath exhaled tidal volumes has proved invaluable in determining optimal inspiratory pressure settings in a population at risk for serious complications from mechanical ventilation. Its ability to differentiate between machine-delivered tidal volumes and spontaneous patient tidal volumes has been extremely helpful in our weaning process. Its unique expiratory block virtually eliminates inadvertent PEEP, and the practitioner's ability to independently fine tune both inspiratory and expiratory flows is an added plus.

However, there have been times when even all of these special features did not allow for optimal ventilatory support in some of our patients and we turned to the Seimens Servo 300 ventilator. The Servo was mainly utilized in its capacity as a volume-limited ventilator to provide assistance to patients not adequately supported with the Babylog 8000.

In traditional pressure-limited ventilation, the inspiratory flow pattern is decelerating and provides a lower peak inspiratory flow rate when compared to volume-cycled breaths. Due in large part to these flow dynamics, the way the lung is filled during inspiration utilizing pressure pre-set ventilation allows for lower peak airway pressures for a given tidal volume when compared to the higher peak inspiratory flow rate and accelerating flow pattern during traditional volume ventilation. Due in part to these flow dynamics, the peak inspiratory pressure with a volume-cycled breath is higher when compared to a pressure-cycled breath for the same tidal volume delivered.

The Siemens 300 ventilator has combined

"8000 Ventilator" continued on page 7

"8000 Ventilator" continued from page 6

pressure-limited breath flow dynamics with a volume-limited breath in its Pressure Regulated Volume Control (PRVC) mode. However, spontaneous breathing is not possible in this mode, as each breath is assisted with a full pre-set tidal volume. Therefore, there is no way to make use of this mode of ventilation when weaning the patient from the ventilator, and the respiratory therapist must switch the patient to a more "weanable" mode, such as volume- or pressure-limited SIMV. The advent of "Auto Mode" on the Servo 300 has allowed the patient to transition between spontaneous and assisted breathing modes. However, this mode does not accommodate those patients who prefer SIMV weaning.

The Drager Babylog has now enabled the respiratory therapist to combine the flow dynamics of a pressure breath while delivering a volume-limited breath in its Volume Guarantee (VG) mode of ventilation. In addition, the practitioner can have these breath dynamics in SIMV, assist control (A/C) and pressure support (PS) ventilatory modes.

Patients in our Newborn Center who appear to benefit from VG ventilation include those with severe RSV pneumonia. These babies often have chest x-rays that show areas of atelectasis combined with areas of hyperinflation, may have a high oxygen requirement, and can often be a challenge to manage on the ventilator. The addition of the VG mode of ventilation to our Babylog has allowed us to maintain the patient on the Babylog and still achieve "volume-limited" ventilatory support with the advantage of pressure-limited flow dynamics.

The major advantage to this style of ventilation over time-controlled, pressure-limited ventilation is that changes in resistance or compliance of the respiratory system do not interfere with the delivered tidal volume to the patient. This function also compensates for variations in spontaneous breathing: the more the patient breathes, the less pressure is applied by the ventilator. The Babylog regulates this volume delivery incrementally from one breath to the next by measuring the exhaled tidal volume of each breath and comparing that to the desired volume, and a new plateau pressure is calculated for the next breath. In this way, the VG mode operates with just the pressure that is necessary to achieve the desired tidal volume, reducing the potential pressure stresses on the lungs.

Another patient population that appears to benefit from this mode of ventilation is the newborn with high abdominal resistance, such as post-operative repair of oomphalocele or gastroscesis. These patients often have changing abdominal pressures, causing dramatic changes in pulmonary compliance that impact our ability to maintain adequate ventilation with conventional pressure-limited ventilation.

The VG mode is also available in conjunction with PS ventilation for patients who have sufficient spontaneous breathing and regulation. The practitioner sets a desired tidal volume, and the ventilator regulates its contribution to tidal volume based on patient contribution. This allows patients to determine their own inspiratory time while still maintaining a set tidal volume with each breath.

The addition of VG to the Babylog ventilator has increased its versatility and ability to provide a wide range of options for the respiratory therapists in our hospital. As with all new technology, it affords the RT and the entire health care team with new and innovative ways to maximize treatment of respiratory diseases. This allows us to continually refine our practices and constantly strive to improve the way we care for our small and fragile patients. ■

Using the Emerson In-Exsufflator

by Joseph Bolton, BS, RRT, Children's Hospital of Philadelphia

At our institution the Emerson In-Exsufflator is used for patients with chronic difficulty in clearing tracheal secretions. The goal of this therapy is to remove secretions and improve air entry, with a decreased need for tracheal suctioning.

A 22-year-old male with a history of Duchenne Muscular Dystrophy was admitted to our intensive care unit for the treatment of congestive heart failure and pneumonia. He was unable to wean from mechanical ventilation secondary to respiratory failure and required tracheostomy. Over the course of his admission, this patient had repeated instances of pulmonary infections. His progressive muscle weakness and decreased ability to cough on his own led to increased problems with retained tracheal secretions. To improve secretion clearance, the Emerson In-Exsufflator was initiated.

A series of rapid changes from positive pressure inspiration to sets of six coughs with intermittent rest periods was used. The coughs gradually increased to 12 coughs per set. A pre-set pressure of +/- 20-30 cm H_2O for both inspiration and expiration was used. To start the coughs, inspiration was delivered for two seconds, then followed immediately by exhalation at two seconds, with a one/two second rest in-between. Each set was followed by a six-second rest period, during which the patient was returned to his ventilator.

Initially, there was some resistance because the patient was anxious being off the ventilator. However, with repeated effort and reassurance, he adapted well to the In-Exsufflaor. Efficiency was judged by comparing pre- and post-treatment breath sounds and the amount of secretions obtained. Eventually, the patient was discharged from our Rehabilitation Unit with this cough therapy added to his daily pulmonary toilet. Six months following discharge to home, this patient remains free from respiratory infection.

The use of the Emerson In-Exsufflator appeared to be an effective aide in secretion removal for this patient. Further comparative evaluations of this and other airway clearance techniques with objective data collection, such as pulmonary function test comparisons, would be valuable. ■

Pulmonary Function Testing in Children

by Joanne P. Elliott CRTT, RPFT, Children's Hospital of Philadelphia

Pulmonary function testing in children is a rewarding and challenging job. It requires all the usual components involved in performing diagnostic studies, along with great patience and determination. The reason it is so challenging is that children have smaller lung volumes to work with when you are coaching them through the maneuvers. Secondly, children between the ages of five and nine are often timid and fearful of any testing done within hospital walls. These two factors, coupled with efforts to achieve reproducibility by the American Thoracic Society (ATS) recommendations (1), can make such testing difficult at times.

One of the most important factors is to completely obliterate the child's fear by creating a fun, non-threatening approach

"Pulmonary Function" continued on page 8

"Pulmonary Function" continued from page 7

that will elicit cooperation. The technologist must develop a trusting relationship with the child before he or she is likely to get and keep the child's attention. This begins with the first visit to the laboratory, where the technologist greets parent and child, sometimes playing a computer game with the child or letting the child color pictures before testing begins. In many cases, the ordering physician sends the child to "visit" the lab as young as 3 years old.

At The Children's Hospital of Philadelphia, it has become common practice to perform the first spirometry attempt at four years of age! This first attempt doesn't always deliver reliable data but sets the tone for future visits. Amazingly, four-year-olds often perform the maneuver well enough to produce a reasonable FVC effort with an FEV1. We'll discuss other modifications in testing applied to children later, but first let's review some basic components of PFTs.

Spirometry

The most commonly performed test is spirometry. According to the AARC Clinical Practice Guidelines for Spirometry (2), the indications are to detect the absence or presence of lung dysfunction, to quantify the severity of known lung disease, or to assess the change in lung function over time or following administration of, or change in, therapy. Spirometry is a screening tool that generates many numeric values; the most important ones used clinically are:

- FVC (L) — Forced Vital Capacity
- FEV1 (L/S) — Forced Expiratory Volume in the first second
- FEV1/FVC (%) — the ratio between the FVC and FEV1
- FEF25-75 (L/S) — Forced Expiratory Flow in the 25-75% of the expiratory curve
- PEF (L/S) — Peak Expiratory Flow

In addition to the above parameters, a graphic representation of this maneuver should be reported. This can take the form of either a volume-time display or, more commonly, a flow-volume tracing. This flow-volume curve can reveal information about the large and small airways that numbers alone may not. It is also a good indicator of the mechanical properties of the lung. A "flow volume loop," as it is commonly called, is usually very unique to each person, much like a fingerprint.

In chronic respiratory diseases, spirometry plays an important role as a tool for the physician in detecting and monitoring airway disease and effective treatment modalities. Spirometry in patients with cystic fibrosis is performed frequently to "catch" a decline in lung function early, thereby increasing the chances for a positive response to antibiotics and inhaled beta-adrenergic medications.

Lung volumes

Other important lung function tests are measurements of lung volume. Lung volumes, which can be performed in a body plethysmograph or by gas dilution technique, provide important information about hyperinflation. Equally important is the indirect information offered about the balance between the static recoil properties of the lung and chest wall. This balance is reflected by the Functional Residual Capacity (FRC), Total Lung Capacity (TLC), and the Residual Volume to Total Lung Capacity Ratio (RV/TLC). Whole body plethysmography measures the communicating and non-communicating airways, whereas gas dilution techniques measure only the communicating airways. In obstructive lung disease, lung volume measurements by both techniques may offer information about the effectiveness of the alveoli in providing adequate gas exchange.

Airway resistance/conductance

Airway resistance (Raw) is a measurement of the opposition to airflow provided by all the airways between the mouth and alveoli. Raw varies inversely with lung volume because the expanding parenchyma exerts traction on the airway walls. Airway conductance (Gaw) examines the capacity of the airways to enlarge as the lungs expand and is linear to lung volume. In other words, the higher the lung volume, the lower the resistance to airflow. This is why Raw is not a very valuable parameter unless it is known at what lung volume the resistance was measured. For this reason, specific conductance (sGaw) evolved as a more valuable parameter, since it makes the adjustment of airway conductance to the lung volume at which it was measured.

Pediatric modifications

In pediatrics, many modifications to the conventional methods of testing can be applied to enhance the possibility of a successful outcome. First, visual imagery becomes necessary in convincing the child to *want* to do the test. Eliciting cooperation from the child is crucial. There's no "making the child do it" in this environment. Children can be stubborn, determined individuals and will win every time in an adversarial situation. A parent may force the child to do the test, but the data will be worthless since the child will be crying or resistant to following instruction.

As the saying goes, "You draw more flies with honey than vinegar." So it is with PFTs in children. We call the body plethysmograph a "space ship," "a car with a sunroof," "a telephone booth" — anything that will spark interest in the child and make him or her want to enter it. We also spend a lot of time teaching the child the concept of blowing out hard and long by using a pinwheel, windsock, and other visual images. When all else fails, we allow the parent to sit in the plethysmograph with the child and make the appropriate corrections for the parent's weight. The words we use when coaching children are very different than those we use when testing adults. For example, for panting, we say, "breath like a puppy dog." For closed shutter breathing, we say, "breath like superman in and out hard."

Of course, we give rewards like stickers and little toys for any effort, even if we didn't get any data. This helps to ensure that the child will want to return for the next visit and almost always creates a happy, cooperative child from whom the technologist is eventually able to get the data requested by the physician.

Agood PFT lab looks at these requests as a challenge and a way to achieve higher standards of patient care through new approaches. Awillingness to try anything - this is the key to success in performing PFTs in children.

References

1. American Thoracic Society. Standardization of spirometry 1994 update. Am J Respir Crit Care Med 152: 1107-1136, 1995.
2. American Association of Respiratory Care. Clinical practice guideline: spirometry. Respir Care 136: 1414-1417, 1991.
3. Ruppel, G. Manual of Pulmonary Function Testing - 6th Edition. Ch. 8. St. Louis, Missouri, Mosby-Year Book, Inc. 1994.
4. Clausen, J. Pulmonary Function Testing Guidelines and Controversies. San Diego, California, Academic Press, Inc. 1982. ■