

# The Next Big Thing

## Leading RT Researchers See New Technology on the Horizon

A brief look back at the history of respiratory care technology shows just how far it has come — from iron lungs in the 1930s to today’s modern ventilators. What does the future hold? We asked three leading respiratory therapy researchers to share their thoughts on new technology coming down the pike.

### Aerosolized Medications and Respiratory Pharmacology

by Joseph L. Rau  
PhD, RRT, FAARC



Making predictions about the future of anything, much less medical therapy, is fraught with peril. However, there appear to be some definite trends in aerosol therapy that can be highlighted.

#### Delivery devices

Aerosol therapy is interesting because it encompasses both delivery devices for inhaled aerosol drugs as well as the drugs themselves. The three most common aerosol generator types — the metered dose inhaler (MDI), the small volume nebulizer (SVN), and the dry powder inhaler (DPI) — will continue

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### Mechanical Ventilation

by Robert L. Chatburn  
RRT-NPS, FAARC

Like other areas of respiratory care technology, much is happening today in mechanical ventilation. For example, we are seeing considerable interest in the development of non-invasive positive pressure ventilation for neonates (NIPPV). A recent meta-analysis reviewed the data on



nasal continuous positive airway pressure (NCPAP) versus NIPPV to prevent extubation failure in neonates.<sup>1</sup> Three studies were evaluated, each of which concluded

that the evidence strongly suggests that NIPPV should be the mode of choice post-extubation.

What we need now is development of the best delivery device.

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### Monitoring Systems

by Robert M. Kacmarek  
PhD, RRT, FAARC

It is very difficult to identify the “next great thing” in cardiorespiratory technology. Clearly, we will see advancement in drugs and their delivery systems, as well as



mechanical ventilators and continuous positive airway pressure technology. However, I do not think we need another new mode or approach to ventilation; yes, we can

expect to see refinements in the existing modes and greater closed-loop or computerized control of the process of ventilatory support. It would seem a sure bet that rise time and inspiratory termination criteria will be automated during pressure ventilation in the near

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“We are seeing developments along three lines of nebulizer technology.”

— Dr. Joseph L. Rau



## Aerosolized Medications

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as device types for aerosolizing medications. Each type of generator has limitations and disadvantages. In broad strokes, nebulizers have exhibited greater development with innovative technology compared to MDIs or DPIs.

I think this may be due to two reasons. First, the phase-out of ozone-unfriendly chlorofluorocarbons (CFCs) as MDI propellants has led to a more difficult transition to hydrofluoroalkane (HFA) propellants than anticipated, causing pharmaceutical manufacturers to look at other types of aerosol generators. And secondly, traditional jet nebulizers were not very efficient with regard to time and size of equipment, providing a stimulus to revamp nebulizers with more efficient models. This has resulted in a move toward dosimetric designs, or nebulizers that generate or deliver aerosol only during inhalation, with no waste during exhalation. An example would be the Monaghan AeroEclipse<sup>®</sup>, a breath-actuated jet nebulizer.

We are currently seeing developments along three lines of technology for nebulizer operation: vibrating mesh designs (modified piezoelectric) such as the Aerogen series or Pari eFlow models, high-pressure micro-spray devices such as the Respimat, and electrohydrodynamic designs such as the Battelle Pharma Mystic. A technical description of these principles can be found in the November and December 2002 issues of *RESPIRATORY CARE Journal*.

Aside from being expensive, all of the newer nebulizer designs deliver increased lung deposition; for example, 35 to 40 percent for the AeroEclipse or the Respimat. There is also a reduction in residual drug (“dead volume”) in the nebulizer and reduced or non-existent ambient loss.

MDI formulations using the newer HFA propellants may give better lung deposition of drug compared to the older CFC-powered MDIs. For example, QVAR (beclomethasone HFA) has a 50 percent lung deposition, compared to the 10 to 20 percent seen with CFC MDIs. This has resulted from a reengineering of the entire MDI valving system for the HFA propellant.

Recent aerosol drugs such as Foradil<sup>®</sup> (formoterol) or Spiriva<sup>®</sup> (tiotropium) were released as single-unit DPIs, much like the old SpinHaler. However, newer DPI designs represented by the Spiros, with battery-powered effort assistance, have been shown to give around 40 percent lung deposition at low inspiratory flows. Such innovations may presage improved designs in DPIs.

## Respiratory medications

At the end of 2004, there were at least 44 respiratory drugs in various stages of development, as reported by *Medicines in Development for Older Americans 2004*. This number was only exceeded by drugs being developed for cancer. Drugs in this group include new long-acting beta-2 agonists; the new inhaled corticosteroid Alvesco (ciclesonide); various monoclonal antibodies for asthma treatment (such as anti-CD25's and anti-IL5's); a respiratory syncytial virus vaccine from Wyeth (in Phase I trials); several influenza vaccines; a new exogenous surfactant, Surfaxin (lucinactant), from Discovery Laboratories; and a single-isomer version of formoterol, arformoterol, from Sepracor Pharmaceuticals. A combination product of formoterol and budesonide (Symbicort MDI) is in Phase III trials. While not all of these drugs will be in aerosol form, the armamentarium of respiratory drug therapy will be increasing.

The combination of more efficient aerosol devices with new and improved drug entities promises a new chapter in aerosol drug therapy. 🦋

Joseph L. Rau is professor emeritus in the cardiopulmonary care sciences department at Georgia State University in Atlanta, GA. He has published more than 20 research studies on aerosol devices and pharmacology.

“Exciting developments in mechanical ventilation will utilize intelligent control.”  
 — Robert L. Chatburn



## Mechanical Ventilation

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VIASYS offers a modified Infant Flow® “SiPAP” system, but it is not patient triggered (for the models available in the United States). I expect to see some new developments in this area and hopefully some clinical research to show that such NIPPV may reduce or eliminate the need for invasive ventilation in some patients.

Another area where clinical outcomes research is needed is for the new “high flow” heated nasal cannula therapy. Can this be substituted for nasal CPAP? How are outcomes affected? Do outcomes justify the greater expense?

On the far horizon, I believe the most exciting developments in mechanical ventilation will be along the lines of “intelligent control.”<sup>2</sup> There has been a steady

evolution in ventilator control schemes over the last decade, with the ventilator becoming more and more capable of making its own management decisions.

In the early days, ventilators were limited to “tactical control,” meaning that the operator was required to enter all the specific settings needed to shape the breath. Newer ventilators offer “strategic control” that allows the ventilator to adjust its own pressure limit to achieve an operator-selected tidal volume target.

However, research has shown the utility of allowing the ventilator to make all the major decisions about the patient, thus enabling “intelligent control.” In the future, we may see more use of fuzzy logic, rules-based expert systems, and even artificial neural networks that can learn to improve their management independent of operator input. 🐼

Robert L. Chatburn is director of the respiratory care department at University Hospitals of Cleveland in Cleveland, OH, and associate professor in the department of pediatrics at Case Western Reserve University. He has published more than 40 research studies on mechanical ventilation and other respiratory topics.

### REFERENCES

1. Davis, P.G., Lemyre, B., & De Paoli, A.G. (2003). Nasal intermittent positive pressure ventilation (NIPPV) versus nasal continuous positive airway pressure (NCPAP) for preterm neonates after extubation [Online]. *The Cochrane Library, Issue 4*. Chichester, UK: John Wiley & Sons. Available: [www.cochrane.org/cochrane/revabstr/AB003212.htm](http://www.cochrane.org/cochrane/revabstr/AB003212.htm)
2. Chatburn, R.L. (2004). Computer control of mechanical ventilation. *Respiratory Care, 49*(5), 507-517.

“We will see advancement in drugs and their delivery systems.”  
 — Dr. Robert M. Kacmarek



## Monitoring Systems

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future. We understand these adjuncts sufficiently to program the ventilator to automatically adjust each on a breath-to-breath basis.

Greater computerized control of ventilation, however, will require a much better integration of monitored data. Here is where I see major change over the next 10 years. If we total all of the independent and interrelated monitored variables available from the mechanical ventilator — the hemodynamic monitor, the pulse oximeter, and carbon dioxide monitors — we end up with more than 50 variables. However, most of these data are never used at the bedside to make decisions! Why? Because they are not presented in an organized pattern that allows the clinician to rapidly identify or predict problems.

Frankly, we do not understand the clinical implications of trends in most of the data that are monitored. As a result, because of the limitation of the human mind, most of these data are not used to make clinical decisions. I expect that over the next 10 years systems that organize these data into clinically useful packets of information identifying a problem or presenting the probability of a specific critical event occurring will become part of the ventilator’s and hemodynamic monitor’s output of information. One can easily envision a specific pattern of data trended over time that would identify an upcoming hemodynamic event or tell us when the patient is ready to wean from ventilatory support. In addition, better trending and organization of data could make alarm systems on all of these devices smarter, eliminating the very high percentage of alarms that are false positives.

The one specific area of monitoring that I expect will vastly change over

the next decade is monitoring of lung volume. Today, we have no bedside mechanism to easily determine lung volume or monitor its change. The use of computerized tomography is too expensive and impractical. But the techniques of electrical impedance tomography (EIT) are developing rapidly and appear to be able to provide bedside continuous monitoring of lung volume. EIT operates by placing numerous electrodes (equal to or greater than 16) around the thorax. Very low current signals are sent and received by these electrodes, measuring impedance of a cross section of the thorax. The greater the air content, the greater the impedance. The preliminary data currently available indicate that these systems would allow us to monitor changes in lung volume globally and locally as the ventilator is adjusted and will assist in identifying the effect of ventilator settings on myocardial function.

In summary, I see a limited injection of new technology over the next decade. However, I expect a refinement of existing technology and much smarter monitoring systems that will allow us to truly use all the data that are currently available. 🦋

Robert M. Kacmarek is professor of anesthesiology at Harvard Medical School and director of respiratory care at Massachusetts General Hospital in Boston, MA. He has published more than 100 respiratory-related research studies.