

# Critical Care News

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## Implementation of a ventilation strategy to prevent respiratory complications

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Paul Ouellet, RRT, PhD (c), actively lectures on the subject of pulmonary recruitment at workshops and respiratory meetings.

## Developing new ventilation strategies and opportunities

For the last three decades, the intensive care environment has evolved together a number of significant aspects that have influenced the ICU: science and research, developing knowledge and strategies applied by ICU caregivers, and advancing technology.

All of these factors play an increasingly significant role, particularly in combination with each other, for the ventilated ICU patient. Each new development may lead to strategies or solutions to overcome complexities that may have been inherent in the ICU past, and provide new opportunities for research and improved patient care.



Nicholas Wyon, MD, PhD with ICU patient after NAVA.

This issue of Critical Care News focuses on how new ventilation strategies and technological developments may lead to new treatment opportunities in some specific Intensive Care departments and patient categories around the world.

#### **Decreasing ARDS and patient-ventilator days by adopting new strategies**

In recent years, there has been an increasing awareness and focus on lung protective strategies as a means of preventing respiratory complications in ventilated patients.

The Edmundston Regional Hospital of Health Authority Four of New Brunswick, Canada, has introduced and applied new pulmonary recruitment strategies with an analgesia/sedation strategy. The treatment strategies have been implemented by a strong interdisciplinary team approach, where the staff have experienced dramatic decreases in APACHE scores, Acute Respiratory Distress Syndrome (ARDS) and a 30% decrease in patient-ventilator days.

#### **Neurally Adjusted Ventilatory Assist (NAVA) in ICU patients in a University Hospital**

One of the largest ICU facilities in Sweden, Linköping University Hospital, has recently taken the challenge and opportunity of evaluating and treating a series of patients with NAVA, a new

generation of mechanical ventilation. The staff share their first experiences with NAVA, and ideas about NAVA in different patient categories in the future.

#### **Magnetic Resonance Imaging and the ventilated ICU patient**

MRI as a means of diagnosis and research has rapidly grown in hospitals around the world in the past decade, and is an area where many hospitals are continuing to strategically invest time and resources.

The complexities and challenges of investigating the mechanically-ventilated ICU patient in the MR environment are well-known, from a local and a global perspective. The University Hospital in Lund, Sweden, shares their thoughts



Peter Reinstrup, MD, PhD with neuro ICU staff.

about a new solution to these challenges that may provide new research opportunities.

#### **Developing ventilatory strategies for protecting the underdeveloped lung**

Premature infants present special challenges in regard to ventilation therapies. At the state-of-the-art NICU of the Albert Einstein Jewish Hospital in Sao Paulo, Brazil, Dr Celso Rebello, has conducted research in surfactant therapy and mechanical ventilation in this patient category for many years.

He shares his experience and ideas about a new means to deliver nasal CPAP, as well as developing technologies for monitoring and delivering respiratory therapy in the smallest of ICU patients.



Celso Rebello, MD, PhD, at the Albert Einstein Jewish Hospital in Sao Paulo.





Surgeon Ludger Blier, MD and Paul Ouellet, PhD(c), RRT, with a post-op patient after initial pulmonary recruitment maneuver.

## Implementation of a ventilation strategy to prevent respiratory complications

The ICU at the Edmundston Regional Hospital, Health Authority Four in New Brunswick, Canada, has experienced a decrease in APACHE scores during the last three years from scores of over 24 to the 15-19 range. In recent years, they also experienced a dramatic decrease in Acute Respiratory Distress Syndrome (ARDS), and a 30% decrease in patient-ventilator days.

These results coincide with the introduction of refined pulmonary recruitment strategies, and implementation of an analgesia/sedation strategy for ventilated patients in the ICU.

Paul Ouellet, PhD(c), RRT, FCCM is a pioneer who contributed to the development of waveforms and loops graphics in mechanical ventilation. He has also been actively involved in lung recruitment and numerous multidisciplinary education activities for nurses, physicians and respiratory therapists. Critical Care News met with Paul Ouellet to hear more about the evolution of lung protective strategies and the current pulmonary recruitment protocol that he has implemented at his hospital.



Paul Ouellet became an early practitioner of lung recruitment procedures, with an interest that started in the late 1980s.

### When and how did the Open Lung methodology first become used at the center?

We were first exposed to the Open Lung methodology back in 1987 through Dr James Snyder and Dr Alison Froese (The Open Lung Approach: concept and application). At that time, the procedure was mainly oriented towards optimization of PEEP. In the early 90's pressure controlled ventilation became very popular and prepared the grounds for the Open Lung concept. Professor Burkhard Lachman came along with his article "Open up the Lung and Keep It Open," which became a strong reference for lung recruitment. Technology at this time allowed for adapting a methodology. This is when we first implemented this protective strategy, by means of waveform and loop analysis. In our experience at that time, recruitment was evident when significant improvement in oxygenation occurred, but was less evident in more subtle conditions of recruitment, and de-recruitment did not appear very obvious from a bedside perspective.

We have done recruitment based on identification of the inflection points a few times, but this technique was abandoned because it appeared less than optimal for us and added more confusion than anything. In order to use the inflection point to determine the opening pressure, a quasi static Volume – Pressure loop is mandatory. Ventilators display dynamic Volume-Pressure loop, and an inflection point is present in almost any condition, especially when resistance is increased under constant flow ventilation (volume ventilation). In time cycled ventilation (pressure ventilation), pressure being constant, the Volume – Pressure loop has an inflection point whatever the condition. The procedure itself appeared problematic.

To perform a quasi static Volume – Pressure loop, PEEP is set to zero and inspiratory flow quite low, prolonging the inspiratory time. In various clinical conditions, where PEEP values  $> 15 \text{ cmH}_2\text{O}$  and  $\text{FiO}_2 > 0,60 - 0,70$  are necessary to maintain adequate oxygenation, this procedure does not appear safe enough for us.

We developed our first recruitment procedures according to the available technology of the 1990's. We relied mainly on loops to establish recruitment and de-recruitment. Volumetric  $\text{CO}_2$  and dynamic characteristics were available at that time but not readily displayed in a way to optimally facilitate the procedure.

### How long have you been using physiological parameters such as $\text{VTCO}_2$ and dynamic compliance in your pulmonary recruitment strategies?

Even though  $\text{VTCO}_2$  and dynamic characteristics were available with the Servo ventilator technology since the SERVO 900 series, it is only with the Open Lung Tool of the SERVO-i platform back in 2000 that we introduced these two parameters to our recruitment procedure. We feel that tidal elimination of  $\text{CO}_2$  is a key parameter with this recruitment methodology, and the dynamic characteristics become a natural complement. The introduction of these two parameters coincided with the contribution of Professor Luciano

Gattinoni on what is now known as the 'recruitment potential' of clinical conditions.

This terminology brought insight to clinical conditions to the point where it became logical to describe lung conditions in terms of recruitment potential. One important element in establishing recruitment potential is to confirm the clinical tolerance of a recruitment procedure from the patient. Once this is established, we proceed to the recruitment procedure. A recruitment potential procedure should reflect the views of opinion leaders.

Our procedure mandates setting the PEEP at 20 cmH<sub>2</sub>O and a Pressure Control level above PEEP at 30 cm H<sub>2</sub>O for two minutes. After this two minute period, we consider this condition as having recruited the lung units that are potentially recruitable. We acknowledge that various conditions can mandate higher PEEP values to keep the recruited lungs open, but for our population, a PEEP of 20 cmH<sub>2</sub>O accounts for almost all the conditions.

We feel that limits of a recruitment pressure should be adapted to the clinical context of each institution. We adopted a recruitment limit of 50 cmH<sub>2</sub>O and should this pressure limit not appear to establish recruitment, more experienced clinicians are solicited by less experienced personnel.

Determining the recruitment potential is certainly the initial intervention that every clinical condition mandates, and every initiation of mechanical ventilation raises the issue as to what is the potential of recruitment.

When mechanical ventilation is necessary for refractory hypoxemia, the Functional Residual Capacity (FRC) is somewhat affected to a certain degree. In order to restore FRC to a functional level, recruitment is certainly a valid procedure. We realized that the sooner recruitment is performed after institution of ventilation, the sooner we can anticipate weaning. By establishing the recruitment potential, we determine the opening pressure early in the course of treatment and it is usually below 50 cm H<sub>2</sub>O.

### **If you look at the mix of patients, how many are surgical versus medical, and how has the recruitment strategy impacted on these groups?**

For more than ten years our ICU admissions consists of 60% medical / 40% surgical, with 10 or 12% of admissions requiring ventilatory support. The prevailing conditions are congestive heart failure, sepsis, and multi-organ dysfunction. Eight years ago, most of our ventilated patients had an APACHE score above 24, with elevated predicted mortality rate. For the last three to two years, the majority of our ventilated patients are now in the 15 to 19 range of APACHE score. This translates in decreased severity index and predicted mortality index, a shortened length of ventilator time. This condition coincides with a decrease in ARDS cases.

Whether these observations are related to the protective ventilator strategy we adopted or a combination of other factors is difficult to determine, but we tend to believe there is a relationship.

### **Have you defined any specific inclusion/exclusion criteria for pulmonary recruitment in different patient categories?**

Of course, common obstructive pulmonary diseases (COPD) need to be addressed on a one-to-one basis. Atelectasis is certainly one of the major indications for lung recruitment. The more familiar we become with this protective strategy, the more we anticipate having exclusion criteria rather than inclusion criteria. Lung recruitment potential is carried out early after institution of mechanical ventilation.

### **How do you view post-operative patients as potential candidates for lung recruitment?**

It is well documented that anesthesia predisposes to atelectasis. We believe that recruitment should not only be limited to ARDS, but every time atelectasis is present or suspected. Atelectasis is really a decrease in FRC, and as far as we are concerned, we have not seen anything in the literature that supports permissive atelectasis as a protective strategy in mechanical ventilation.

### **How do you experience the relationship between the recruitment strategy and outcomes?**

In our population, we believe there is a definite relationship; fewer patients need ventilation, and ventilated patients are not as sick as they were seven, eight years ago. One should not forget that the APACHE score is based on the worst clinical signs over 24 hours after admission. Within the first 24 hours, non protective ventilation strategies can inflict lung injury, thereby increasing the APACHE score. For the last three consecutive years, most of our patients on mechanical ventilation are in the 15 to 19 range of APACHE score.

Higher APACHE scores were noted prior to the initiation of lung protective strategies in place. We also modified our analgesia/sedation protocol to incorporate the Bispectral technology, and that might also have contributed as well to decrease APACHE scores. For that purpose, we tend to believe that our ventilation strategy brought a positive contribution to the global picture.

Implementing recruitment and protective strategies of ventilation is one thing; staff training and maintaining abilities is another concern. Institutions should be proactive in keeping proficiencies in clinical skills. We believe that it is only with planned continued education and seminars that patients will benefit more from the technology. The clinical skills of a bedside provider directly impacts on patient care. For that purpose, lung recruitment should be part of an institutional culture.

With such an embedded culture, recruitment is timely carried out as de-recruitment occurs and is recognized. De-recruitment can occur rapidly, or discretely as a slow process. Therapeutic beds with automated rotation can be a source for de-recruitment on a completely paralyzed patient. With proper training, bedside clinicians can easily detect patient-ventilator asynchrony and evaluate the impacts on "Open Lung Status".

For that purpose, the Open Lung Tool is a major contribution to patient monitoring. By trending and displaying VTcO<sub>2</sub> and





Paul Ouellet is known for his lectures and presentations about pulmonary recruitment strategy combined with strategy for sedation and analgesia. He frequently conducts lung recruitment seminars in the course of his work.

dynamic characteristics, the SERVO-i readily brings valuable parameters to the skilled clinician. Our recruitment protocol incorporates these important parameters towards a recruitment maneuver as soon as de-recruitment occurs. By recruiting in such a timely manner, we observed that recruitment resumes over 10 to 15 breaths thereby preventing complete alveolar collapse.

We feel that skilled clinicians could contribute to a technology that could interact with a patient by automatically carrying out recruitment maneuvers under preset conditions thereby closing the loop in opening the lungs and gently keeping them open.

### Can you give us a specific patient case as an example?

We recently had a patient who underwent a left lower lobectomy. Fourteen days post operative, he developed massive collapse of his left lung that would have been traditionally treated with a bronchoscopy. Intubation and mechanical ventilation was instituted. Over an eight hour period, recruitments at 50 cm H<sub>2</sub>O carried out every hour re-expanded the collapsed lung without the need for a bronchoscopy. Proper PEEP to prevent de-recruitment was set, and titrated down as the lung mechanics improved over the next 24 hours. A recruitment protocol should have set endpoints over a set

period of time. Proper analgesia/sedation is also part of the equation and must be adapted to the ventilation strategy, as improper analgesia/sedation can lead to asynchrony, de-recruitment and ventilator induced lung injury (VILI).

### Can you tell us more about your strategy for sedation and analgesia?

We provide analgesia/sedation for ventilated patients through a protocol: fentanyl or morphine as the opioids and midazolam (Versed) as the benzodiazepine. Analgesia and sedation are carried out to assure patient comfort. In conditions where FRC is decreased to a point where invasive ventilation becomes necessary,



Internist Chantal Violette, MD and Paul Ouellet work closely as interdisciplinary team members.

we believe that, as clinicians, the least we can do is to provide comfort to a patient who has to comply with a technology that can cause more harm than good. Often neglected and carried out without endpoints, analgesia/sedation must be addressed as seriously as the ventilation strategy. We believe that patient – ventilator interaction and analgesia/sedation cannot be dissociated.

Generally speaking, during the first 24 hours of ventilation with oxygenation problems, patients are sedated to the point where they will become apneic. Opioids have direct impacts on the respiratory centres and benzodiazepines add to the sedation. One major drawback to this condition is

over sedation on one end of the spectrum and under sedation on the other end.

We adopted the bispectral technology to guide our analgesia/sedation protocol. This has brought a technology at the bedside that provides valuable data not otherwise obtainable by any other means. Bispectral technology, and for that matter, any other EEG processed technology is more valuable than subjective scales like the Ramsay scale to describe deep sedation conditions. The BIS guided protocol prevents under and over sedation. Over sedation is quite a common situation for ventilated patients. Our preliminary data show those patients with BIS guided protocols have shorter time to extubation

than a Ramsay scale guided protocol, also with less patient – ventilator asynchronies. We feel that BIS technology has its niche in intensive care as much as in anesthesia.

#### **When did you start using bispectral technology?**

We started using BIS in intensive care about four years ago. One aspect of my research was to establish correlation between the Ramsay scale, the Sedation and agitation scale and BIS technology. We established the correlation among these three tools, in the perspective of patient – ventilatory asynchrony. In the first group analgesia/sedation was guided with the





Louissette Plourde, RRT, with respiratory therapy colleagues. The hospital is a teaching center for other institutions.

Ramsey scale measured every four hours. The second group was guided with BIS. Preliminary data show that with a Ramsey score of 6 (deep sedation), asynchrony can occur whereas in the BIS guided group, a BIS value in the 40 – 60 range demonstrates less patient – ventilator asynchronies.

BIS is a composite number whereby an interpretation algorithm of EEG activities generates a value between 0 – 100.

A value of 0 is associated with cortical suppression and 100 with maximal activities. BIS values between 40 and 60 are generally associated with an adequate range of cortical activities. Values below 40 are considered over-sedation in most clinical conditions. An interesting feature of BIS technology is that it monitors EMG activity of the frontalis muscle of the forehead. Initially considered as a confounder, EMG might be a pre clinical

pain expression indicator. For non communicative patients, this might prove a useful parameter not obtainable with conventional pain assessment scales. Behavioral scales to evaluate pain on non-communicative patients are centred on three axis: facial expression, upper limb movement, and patient – ventilator interaction. This concept is well documented mainly by Dr Jean-François Payen of the Université de Grenoble in France. We tend to believe that BIS might be the instrument clinicians have been waiting for to monitor brain activities in critical care during deep sedation states in order to adapt a treatment that will perhaps facilitate patient – ventilator interaction.

In order to add more flexibility to provide adequate analgesia/sedation in a context of patient – ventilator synchrony, Propofol (Diprivan) is included in our protocol as a rescue medication for conditions where maximum doses allowed by the analgesia/sedation protocol are reached without synchrony, and where neurologic conditions mandate rapid emergence from the sedative state.

Green supports that the psychological profile prior to ventilation support has an impact on the recovery, and the importance of delirium in intensive care is often too easily neglected. An interesting article by Richman demonstrated that the incidence of patient – ventilator asynchrony is decreased by using a perfusion of fentanyl and midazolam.

Impacts of patient – ventilator asynchrony are real; de-recruitment, ventilator induced lung injury and ventilator associated pneumonias (VAP). Our VAP rate is presently 5/1 000 patient ventilator days, and this represents the low incidence of complications for ventilated patients and reflects a global approach for ventilation strategies implemented. For that purpose, I feel ventilation strategies must develop hand in hand with better strategies of analgesia and sedation. Neurally Adjusted Ventilatory Assist (NAVA) is a promising technology that might have an impact on analgesia/sedation needs in ventilated patients. Preliminary data suggests that this technology demonstrates a marked decrease of patient – ventilator asynchronies for spontaneously breathing conditions.

Achieving patient – ventilator synchrony in non spontaneously breathing patients often mandates deeper sedation states. These conditions are more effectively monitored with BIS technology. Adapting ventilation strategy to control  $\text{ETCO}_2$  below the threshold of apnea can be an option that is worth exploring. Proper ventilation backup is nevertheless essential in these conditions.

#### Can you share any patient cases in this respect?

Recently, in the middle of the night, a patient experienced an asynchrony episode that took us by surprise. A neuromuscular blocker was judged appropriate to achieve synchrony. The next morning, readjustment of the ventilation strategy to allow recruitment and adequate analgesia/sedation guided with BIS resumed ventilation without the

need for neuromuscular blockers. By lowering  $\text{ETCO}_2$  by 2 mmHg from baseline suppressed spontaneous breathing and synchrony was established. We have not done comprehensive comparative studies to support this strategy but we definitely feel that analgesia/sedation and protective strategies of ventilation go hand in hand. By concentrating only on the ventilation strategy one side of the equation is missing; i.e. analgesia/sedation for synchrony.

#### What do you see as future challenges or opportunities in regard to pulmonary recruitment?

Our current recruitment procedure was developed through consultation with opinion leaders in the field. We explored various recruitment strategies and developed our own, based on the kind of patients we treat and SERVO-i

technology. We have been influenced mostly by physicians such as Fernando Suarez-Sipmann, Luciano Gattinoni, John Marini and Marcelo Amato. We feel that there are different ways to restore FRC. A successful protocol implementation mandates a well planned education program coupled with clinical support. Over the years, our recruitment procedure has been continuously updated and transformed as literature has brought new evidence and as technology evolved. In my opinion, NAVA, is the next generation of technology and certainly has tremendous potentials. In this respect, I also believe that a future challenge for technology will be to provide a clinician directed automated recruitment strategy that could re-establish FRC immediately as de-recruitment occurs. As an illustration, we think that the present status in ventilation can be summarized as follows:

- A poor ventilation strategy creates ventilator induced lung injury
- A fair ventilation strategy treats complications
- A good ventilation strategy prevents respiratory complications



Paul Ouellet has authored and co-authored many peer-reviewed articles and textbooks.

#### Biography

Paul Ouellet, PhD(c), RRT, FCCM, is a registered respiratory therapist and a Fellow of the American College of Critical Care Medicine. He is team leader of the ICU multidisciplinary team and clinical specialist at Edmundston Regional Hospital, Health Authority Four in New Brunswick, Canada. He is also Associate Professor, Department of Surgery at Sherbrooke University, Quebec Canada, and PhD candidate at the Faculty of Medicine at Sherbrooke University. Paul Ouellet has authored and co-authored several peer-reviewed articles and textbooks, and has lectured on the Open Lung concept throughout Canada. He is also actively involved in numerous multidisciplinary education activities for nurses, physicians and respiratory therapists.

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# An interdisciplinary approach to pulmonary recruitment: OR/anesthesia

The intensive care unit of Edmundston Regional Hospital, Health Authority Four of New Brunswick has an annual average of 900 admissions and 2,500 patient days, with 11 % of admitted patients receiving mechanical ventilation.

The pulmonary recruitment strategy is utilized over a multidisciplinary range of staff, including 16 respiratory therapists, 30 full time nurses in the ICU, and critical care physicians. Lung recruitment is also a priority in the OR during anesthesia.

Critical Care News had the opportunity to meet with various staff members and discuss the pulmonary recruitment and sedation strategies.

Dr Daniel David has been working as an anaesthesiologist since the early 1960s and joined the staff at Edmundston Regional Hospital in 1970. Early in his career, Dr David was exposed to sustained inspiratory maneuver before emergence from anesthesia and it has been part of his routine practice throughout his professional practice.

**The pulmonary recruitment strategies here have led to some impressive results. How do you regard the need for recruitment in anesthesia?**

**Dr David:** I firmly believe in lung recruitment. When I started out many, many years ago in 1959, I provided ventilation and recruitment in anesthesia by means of my hands by bagging the patient. I continued to provide recruitment, which was made even easier when we came to our current system, which provides pressure controlled ventilation in anesthesia. I think it is particularly important, for patients who are lying supine on the OR table for three, four or five hours, to consider that atelectasis is likely to occur, thus decreasing their functional residual capacity. What I usually do upon emergence, is to provide pressure controlled ventilation at approximately 40 cm H<sub>2</sub>O for 10 to 15 breaths. I firmly believe the anesthetized patient needs to have his alveoli recruited.

**So you firmly believe in the relationship between anesthesia and atelectasis?**

**Dr David:** Yes – I can use an analogy – you can sit in the cockpit and only work the controls, but I feel it is more appropriate to understand how the engine works before looking at the controls. With a thorough knowledge of the workings of the engine, you can appropriately guide your aircraft, or in our case, adapt the appropriate therapy to the patient. By choosing only to sit at the control deck, you are only sitting at the controls and perhaps not optimizing the whole flight.

I have appreciated the benefits for lung

recruitment in anesthesia for many years. In olden days manual ventilation was carried out by the 'Educated hand'. Lung recruitment can be carried out quite simply, without ceremony; technology is instrumental to proper patient care.

**And how do you perceive the patients receiving recruitment in the OR when they come to the ICU?**

**Paul Ouellet:** The wonderful thing is that patients from the OR are generally easy to ventilate, if atelectasis is reversed in anesthesia; and when we institute ventilation in ICU, we do recruitment, unless patient condition prevents such



Anesthesiologist Daniel David, MD and Paul Ouellet have shared a close collaboration for many years.

maneuver. In this institution, lung recruitment here is part of our culture. Usually for post-op patients, they are extubated the following day, if not within the first twelve hours, with very few developing atelectasis. Dr David has been a very good precursor in numerous aspects of anesthesia and in critical care. I remember when I started my career; one of the first strategies in ventilation Dr David taught me was be aware of atelectasis and prevention through sustained deep inspirations. Adapting this basic physiology principle with a new technology confirms years of experience gathered through experienced clinicians like Dr David. The concept of lung recruitment is not a new invention, but technology helps us refine ways of adapting this concept in clinical applications.

#### So there is a cross-disciplinary acknowledgement of the value of recruitment?

**Dr David:** Yes. We normally have cardiovascular surgeries, thoracic surgeries, with the majority of our procedures being orthopaedic surgeries. We have five anesthesiologists on staff, and on a daily basis, we anesthetize an average of 5-6 patients for surgery, lasting

anytime between 30 minutes to several hours. Nevertheless, 30 – 45 minutes is enough to inflict atelectasis in otherwise healthy lungs. The endpoint is that we feel that recruitment helps to maintain the lungs open and thus avoids the start of an inflammatory process that could eventually spread to healthy lung regions and other systems and organs.



Dr Daniel David has been on staff at Edmundston for over 35 years.

#### Biography

Dr Daniel David received his initial education as an anesthesiologist at the University of Madras in 1963. After specialist training at McGill University in Montreal, he joined the staff at Edmundston Regional Hospital as an anesthesiologist in 1970. He has been actively working as an anesthesiologist on staff there ever since.

## An interdisciplinary approach to pulmonary recruitment: Critical Care/ICU

Dr Chantal Violette, Internist of the multidisciplinary team, Nurses Manon Dionne and Anne Caron and Respiratory Therapy Manager Louisette Plourde related their experiences and perspectives in regard to the implementation of the pulmonary recruitment and sedation strategies.

#### What is your experience of the interdisciplinary approach, and how do you think it is working?

**Dr Chantal Violette:** Our ventilated patients recuperate well. The Open Lung strategy does work for us, no question about that, and we adapt patient-ventilation synchrony with the analgesia/sedation strategy through

protocols. In this institution, all of these issues are interrelated and must be regarded as such. That is why we have interdisciplinary teams.

**Manon Dionne and Anne Caron:** We nurses are concentrating more on the sedation and analgesia protocol and monitor the patient – ventilator interaction by working closely with the respiratory

therapists. We feel we are keen at looking at the ventilator and when we notice patient – ventilator asynchrony, we titrate analgesia accordingly. We start with opioids and titrate within 20 minutes if necessary. It has become part of our culture now to determine if the patient is in asynchrony, and if so, we explore the possibility of de-recruitment. Now that we implemented BIS technology to guide



Louise Plourde, RRT, has observed a 30% decrease in ventilator hours per year.

analgesia/sedation, we can hardly think how we did before to adapt ventilation strategies without quantitative monitoring of both sedation and ventilation.

**Paul Ouellet:** When you introduce a new technology in the ICU, you have to ask yourself, what impact will this have on patient outcome? If you don't know how to use it well, do not implement it. If you do know how to use it and utilize it accordingly, and if it translates into better patient care and outcome, why should you restrain its use? We feel that when we introduced SERVO-i with Open Lung Tool, we have bought technology that has an impact on patient outcome. When we introduced the BIS technology, we also felt that it had an impact on patient outcome. I can remember with older platforms and learning of the Open Lung concept that it was a revelation to us, which made so much sense. When implementing waveforms I remember speculating at one point, would the expiratory limb of the volume-pressure loop be more interesting than the inspiratory limb? Of course, now it is obvious that the expiratory limb reveals its secrets. So we have seen the evolution of this concept, and now we are at the stage where the technology

enables us to have the endpoints for recruitment. With the VTCO<sub>2</sub> and dynamic compliance, we now have two valid parameters to establish the level of recruitment or de-recruitment. As this technology evolves the physiological concept remains the same. But we have better tools to interpret and deliver therapy.

#### How many respiratory therapy staff members do you have?

**Louise Plourde:** We have a total of eighteen respiratory therapists to cover the ICU and an outpatient pulmonary clinic. I have been working here for 22 years, and have seen numerous changes, from old piston ventilators to the technology we are using now.

#### Regarding the pulmonary recruitment protocol and strategy for sedation and analgesia to prevent ventilator asynchrony, can you tell us about what you have observed since this has been implemented?

**Louise Plourde:** Preliminary data demonstrate the positive impact of these implemented strategies. The number of ventilator-days decreases and we observe

less agitation, easier and shorter weaning time and affected length of stay in ICU as well. We are in the process of precisely quantifying the results and submitting them for publication.

#### Have you noticed the decrease in APACHE scores?

**Louise Plourde:** Previously, most of our ventilated patients had average APACHE scores of 24; whereas now, the average score is more in the 15 – 19 brackets. This translates into less acute conditions. This coincides with the introduction of the Open Lung protocol and the BIS technology.

Since the introduction of these procedures, on an annual basis, we roughly have the same number of ventilated patients, but we notice a 30% decrease per year for ventilator hours; that seems striking evidence on positive impacts. This trend seems to continue this year as well and we are tempted to interpret this observation as a logical endpoint towards optimal and adapted patient care.

#### What has been the experience of training your RTs when implementing the new pulmonary recruitment strategy?

**Louise Plourde:** We have an orientation program which every RT must comply with prior to work in ICU. Every RT must be certified for each protocol, and an annual recertification is mandatory. For newcomers, it generally takes a full year before a therapist is fully operational with full delegation, in airway management, ventilator management, sedation and analgesia, and hemodynamics.

As therapists, we have established a clear role from a clinical point of view, and we work closely with the multidisciplinary team so that means that the educational bar is quite high. All new RTs from other centers must to some extent re-learn, so that they understand the multidisciplinary approach. Most of the students here on clinical rotations in their final year experience that we are establishing quite high requirements and standards. We incorporate them in the ICU.



**In regard to the multidisciplinary approach to the protocols you are using, do you have team meetings on a regular basis?**

**Dr Chantal Violette:** The prerequisite to a multidisciplinary approach is to work as a team, which means close and regular contact with each other. We have daily rounds with each function represented, on every patient, with a nurse, respiratory therapist and physician attending. In all aspects of care, we have a continual dialogue in close proximity to each other.

**When you switched the ventilator fleet over to the new fleet, was this a challenge from a training perspective?**

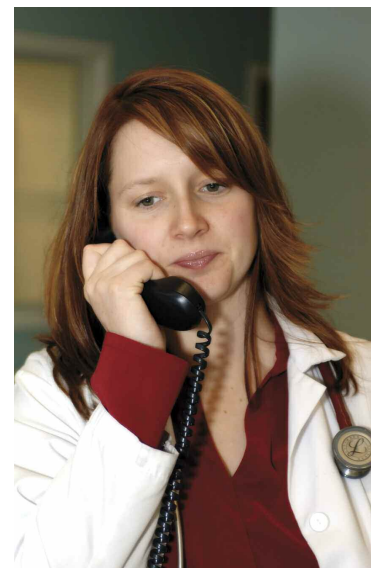
**Louissette Plourde:** Not necessarily, mainly because it was a gradual process. As a new platform was introduced, in service was carried out over a period of time that would allow every member of the staff to become totally familiar before moving to the bedside. We were not rushed to the bedside, and that attitude created a sense of security for all members of the multidisciplinary team.

For some of our younger therapists, the Servo ventilators are the only platform they have mastered in such depth. We

feel it becomes a significant advantage to have only one platform that everybody is familiar with when it comes to adults, children and infants. Versatility from all categories of patients was one of our first criteria when we changed the fleet. From a clinical rotation perspective, students from Université de Moncton, University of New Brunswick in St John, Dalhousie University in Halifax, Sherbrooke and Chicoutimi Colleges in Quebec, are aware of the only platform we are using and this allows for very precise objectives in their curriculum. The clinical rotations have very precise objectives directed towards the Servo platform. Instead of having several platforms, we opted for several academic institutions. This has served us well in recruiting RTs that fit in our team. This is important, particularly in smaller institutions like us, where we work very closely together, with synchronized objectives.

**As responsible for the respiratory therapists here, what do you see as strategically important in regard to future therapies?**

**Louissette Plourde:** We have good reasons to believe we have made the right decision when we opted for the Servo platform. Neurally Adjusted



Chantal Violette, MD.

Ventilatory Assist (NAVA) is certainly the most obvious example to support this statement. We anticipate NAVA as a logical forward movement in mechanical ventilation, and as a teaching institution, our challenges to incorporate neurophysiology in mechanical ventilation are quite stimulating. We feel NAVA will bring a new dimension and will serve as a logical complement to conventional ventilation.



As interdisciplinary team members, nurses Manon Dionne and Anne Caron are active in monitoring patients on the protocols.



Dr Nicholas Wyon and patient after completion of ventilation therapy and NAVA.

## First experiences with NAVA in a University Hospital setting

The ICU at Linköping University Hospital faces the challenges that characterize many ICUs in that setting: large numbers of patients and a hectic pace for staff members. As one of the largest ICU facilities in Sweden, they have also recently taken the challenge and opportunity of treating a series of patients with a new generation of mechanical ventilation; Neurally Adjusted Ventilatory Assist, or NAVA.

Critical Care News spoke with the ICU Chief Consultant Nicholas Wyon, MD, PhD and his colleague Taichi Kadowaki, MD to hear about their first experiences with NAVA in different patient categories.

### Could you begin by generally describing your ICU operations and size here?

Our facility operates as a general ICU, with a combined ICU and post-op department. We have 11 ICU beds with full monitoring and ventilation, although we are generally staffed for the care of 8 patients. Additionally, we have a post-operative department with 24 beds where the number of patients may vary at different times throughout the day. We may have up to 24 patients during daytime hours and about 8 patients at nighttime. On an annual basis, we treat between 750 and 800 patients, which makes us one of the largest ICU facilities in Sweden.

### Which types of patient categories do you encounter most frequently?

In general terms, we have about a fifty-fifty division of cases that are medical and surgical, although I think that the surgical arena is generally our biggest customer, closely followed by medical and infection clinics. This university hospital has specialized intensive care units for cardio/cardiothoracic and neurological patients, so we do not treat these patient categories.

### When did you first become familiar with the concept of NAVA?

The first time I was exposed to the concept was at a European Intensive Care meeting a few years ago. Researcher Christer Sinderby presented a film of a young woman connected to a NAVA catheter, an older generation ventilator and a test lung. She talked and breathed, and the test lung followed every movement that she made. I was very impressed by the concept, and was eager to know if it would work as well in a clinical situation. This film and the synchrony it displayed made a deep impression on me, I found it to be quite extraordinary, and it was as if we were seeing a model of the woman's lung outside of her body. Earlier this autumn, we were approached by developers that we have had contact with in connection with lung recruitment seminars, and they wanted to know if we were interested in collaborating in clinical evaluation of the



Dr Nicholas Wyon is head of the ICU at Linköping University Hospital.

NAVA system. Obviously, we were pleased by this opportunity to collaborate.

### Initially, was it difficult to learn the theoretical details of the application before treating your first patients?

My perception was that the application was easy and very intuitive. Once you establish what Edi is (electrical activity of the diaphragm), and how to determine Pressure Support in relation to the Edi signal, it was very easy to understand how to influence the application both ways.

### In general, which ventilation therapies are most commonly used here?

The majority of patients are treated in Pressure Control, and are weaned by means of Pressure Support, in about 95% of cases. A few patients are treated with

Volume Control or Pressure Regulated Volume Control, but these cases are less common. Since we do not treat neurological cases, which are perhaps more dependent upon constant minute volumes and end tidal CO<sub>2</sub>, and since we maintain very high staffing at bedside, we can react very quickly if tidal volumes vary. We generally work on the basis of clinical monitoring by staff members, with equipment to be regarded as support tools.

### In regard to staff members, who are involved in the NAVA clinical evaluation at the present time?

At the present time, we have limited the number of staff involved, as our current protocol requires me as head of the unit to be present during therapy. Other staff members have been present and observed the procedure, but only I and



one of my colleagues have implemented the protocol. But when we have explained the set up for our colleagues, about how the system senses the contractility of the diaphragm, they understand the possibility of patient-ventilator synchrony immediately and intuitively.

**As you go forward, gaining more experience and more patient treatments, do you think it will be a challenge to educate the rest of the staff on the concept, application and practical aspects such as catheter placement and interpretation of Edi signals?**

I do not think that this will be difficult, rather that it will be something that the other staff members learn fairly quickly. Based on my own experience, it was much simpler than I expected it to be.

Above all, I think that the four ECG signals as a support tool are very effective and easy to see when determining catheter positioning. And in any case, I find the ECG signal tracings to be something very valuable at the bedside. For example, esophagus ECG signals can be an invaluable support tool in mapping out an atrial arrhythmia, if a P wave is present or not, something we do not traditionally see on conventional ECGs. To be able to receive esophageal ECG signals as well as NAVA as a ventilatory application is very positive.

**In the patients you have treated so far, have you had experience of the catheter in use both as a means of obtaining Edi signals as well as a conventional feeding tube?**

Yes, we start enteral nutrition at a very early stage here, most frequently from the first day. Since NAVA by nature enhances the weaning process, the patients we have treated with NAVA have already been in the ICU for some days and are receiving full enteral nutrition. We have had no difficulties with the dual functionality of the catheter to obtain Edi signals and as well as to deliver nutrition.

One early practical aspect that we had commented on was the catheter coating, which has a very slippery surface and required some attention in aspects of placement. A normal feeding tube can glide a little up and down, which has little significance in regard to feeding. But for NAVA, it must be stable in a manner to avoid signal movement and signal disturbances. Our feedback helped the developers find a solution to resolve this problem.

**How do you perceive the Edi curve?**

In regard to our initial experiences, we have perceived the value of having the Edi curve as a portion of the display. It supports us determining which actions we should take. If I see a low Edi, I know I maybe must reduce the level of Pressure Support, to obtain a higher Edi. Naturally, at the same time we want to avoid hypoventilation, so it is a balance in tuning, and in this respect it is valuable to have the Edi information available.

**How is it when you compare Edi signals with harmonious, graphic pressure/volume curves?**

I can see where this might be a cultural transition for some, but the fact is that we are treating human beings who are rarely "symmetrical" patients. If the patient also has something that is influencing consciousness, or a brain stem disturbance, it is a challenge, and an area where I think we will really see an advantage in having NAVA, not just in our everyday cases that trigger with regularity, but in our problematic patients who do not trigger properly, who breathe irregularly, or cycle off much too quickly. In the ICU, we all see an endless flora of respiratory dysfunction; I believe that NAVA will be an important instrument in the treatment of these cases. I especially



Dr Nicholas Wyon with COPD stroke patient, recovering from pneumonia.

like the fact that the system simultaneously monitors Edi and pressure triggering, and responds to the patient need accordingly. This provides safety, so that we know that if for some reason there is a problem with the Edi signal, the patient will receive a pressure supported breath, or controlled breath in case of apnea, which we are so familiar with, as a back-up.

**You have observed various types of patients so far in the trial; a 70 year old acute myocardial infarction patient, an older patient with pneumonia, and a younger Downs Syndrome patient with pneumonia as well. What are your general observations and impressions at this point?**

My impressions of NAVA are very positive at this point. For example, the boy with Downs Syndrome was a case where I was doubtful if we could treat him unsedated in the ventilator at all. He was very agitated when we started the ventilator. I was concerned that he would panic as soon as he woke up and felt the tubes, and start pulling things and becoming more agitated. But he became calm when we started the protocol with Pressure Support, and was very calm when we switched over to NAVA. In our first attempt at NAVA, we did not feel that we received optimal Edi signals, but we tried again the following day, when the boy was more lucid and awake, and NAVA worked extremely easily and well. It was a pleasure to see an otherwise potentially difficult patient, with reduced mental capacity and anxiety, to observe him peacefully receiving his NAVA ventilation, watching TV and generally happy with no difficulties at all.

In regard to the AMI patient that was mentioned earlier, this patient also had periods of apnea, but NAVA functioned just as well as Pressure Support in this patient.

**On the basis of these initial experiences with NAVA, what would you recommend to other ICUs as important factors in implementing NAVA?**

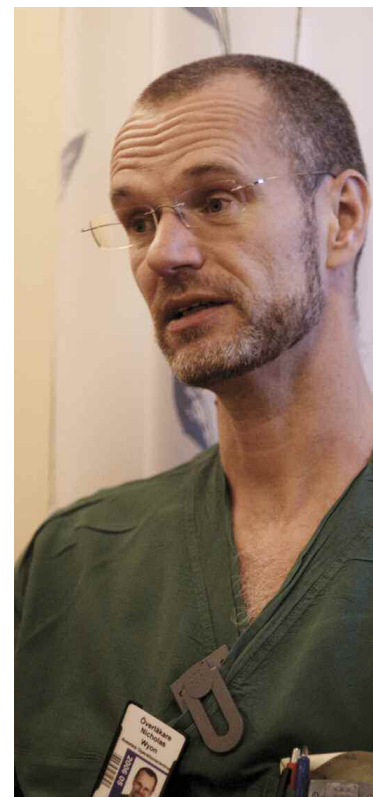
As NAVA becomes commercially available, I think it is very important to

select the right patients to begin with. I would recommend starting with uncomplicated cases, in a specific category first, in order to gain experience in easier cases from the beginning. I think a good general rule when trying new therapeutic options is to focus selectively and gain experience at first, without trying out something new in all sorts of cases and categories. I would choose a category with a calm patient with unimpaired mental capacity, and learn about the system on the type of patient that would probably do well in a conventional ventilation mode, such as Pressure Support. I think it is important to familiarize yourself with the system before going on to more complex cases, although eventually the complex cases are the ones where we are most interested in the potential benefits of NAVA. To summarize, begin using NAVA with the simple cases, and gain experience to be comfortable and secure with the method.

**As you continue to gain experience and collect patient data in the coming months, what are the more complex or challenging patient categories that you personally are most curious about?**

Personally, I believe that we have a potentially very interesting NAVA patient category: we have a rather large scale operation for scoliosis surgery in pediatrics with various neurological factors. We have about 50 cases per year of what we call neurogenic scoliosis of different syndromes, neuromuscular diseases, which present a rather complicated respiratory situation peri-operatively. These patients are subject to comprehensive spinal surgical procedures, and come out of the OR with a thorax drainage tube. We currently have a policy to try to extubate these patients as quickly as possible, to encourage spontaneous breathing. Now and then, they might have set backs, due to immature respiratory regulation. This is a patient category where I think NAVA might provide some interesting advantages, and these patients often are too fatigued to pressure or flow trigger the ventilator, or may not be able to do so due to irregular breathing patterns. The potential advantage of diaphragmatic trigger with NAVA might provide an extra dimension in treating these patients. But we are not

quite there yet; we need to acquire more experience with NAVA on less complicated patient categories at the present time.



Nicholas Wyon, MD, PhD.

### Biography

Nicholas Wyon, MD, PhD, obtained his initial medical degree at the University Hospital of Linköping, Sweden. He thereafter received his degree in anesthesia and intensive care. Nicholas Wyon received his advanced Medical Doctor degree and completed his PhD degree at the Karolinska Institute in Stockholm, Sweden.

He has previously worked in the departments of Anaesthesia and Intensive Care at Linköping University Hospital and St. Görans Children's Hospital in Sweden. Nicholas Wyon has been Chief Consultant of the Department of Anesthesia and Intensive Care at Linköping University Hospital since 2003.



Taichi Kadowaki, MD, has worked with the NAVA pre-validation study.

ICU physician Taichi Kadowaki, MD, has been involved in the NAVA clinical evaluation since it started at Linköping University Hospital. He shared his initial patient experiences and observations regarding the future to Critical Care News.

**Can you tell us a little about your background, and how you were familiar with the NAVA concept, prior to starting the clinical evaluation?**

I conducted my medical studies here at Linköping University and received my education as an anesthesiologist in Visby, Sweden. But I have worked primarily within intensive care here in Linköping for the past 6 years.

I had read about NAVA in medical literature and physiology textbooks, and

had also heard about it from colleagues who attended presentations and seminars in international congresses.

**In a practical aspect, has it been difficult to apply NAVA, interpret Edi signals or place the catheter?**

No, it has not been difficult; in fact I have not put much focus on these practical details, but have spent most of my time understanding the principles of NAVA by observing the patient ventilator interaction.

**Can you share your most recent patient experiences with NAVA?**

The most recent experience we had this week was with a COPD patient, whom we believe suffered a stroke, resulting in pneumonia. We often see respiratory complications in connection with cerebral capacity impairments. He did well on NAVA, and is now spontaneously breathing again.



### What are your general impressions of NAVA so far?

I find it very easy to apply. I believe that much of the latest research in regard to mechanical ventilation is in connection with improved interaction between the patient and the ventilator. The main issues are of patient comfort, and faster and easier methods of weaning. At present, it is of course too early to state any opinions in regard to outcome or mortality. It will be very interesting to study NAVA on patients with more complex respiratory situations.

### In regard to what you have observed with NAVA at this stage, do you feel that the patients are in synchrony with the ventilator?

Yes, I do. At this stage, we have not had very complex cases, but have observed patients receiving pressure supported ventilation as conventional therapy as a part of the protocol before we switch them over to NAVA. But I see opportunities with the types of patients that are not in synchrony, and the potential to help them achieve synchrony with NAVA.

### Based on the current experience you have, how would you advise other ICUs who might be interested in using NAVA? What is most significant in this respect?

I do not believe that NAVA requires much practical preparation. It is important to fully understand the concept before starting, which is a prerequisite with any new form of therapy or application. Technology evolves quickly, and that which appears to be self-evident may not always be so. It is also difficult to educate and train staff on all different types of equipment in the ICU, which makes it even more important that everyone fully understands the physiological concept with a new method, so that it becomes more or less routine during implementation.

### In your opinion, which patient categories are you most interested in regarding NAVA in future?

Personally, I am most curious to see NAVA in non-invasive patient categories. I am excited to see how it will work, for example in non-invasive COPD patients.

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Taichi Kadowaki, MD.



Peter Reinstrup, MD, PhD with staff member and neuro IVA patient, after conclusion of ventilation therapy.

## New opportunities for MRI examinations of ventilated ICU patients

The neuro ICU of the University Hospital of Lund serves several regional hospitals in southern Sweden in a population uptake area of 1.8 million inhabitants. They experience the same obstacles and challenges that most neuro ICU departments encounter when transporting a ventilated ICU patient for magnetic resonance imaging examinations.

Critical Care News spoke with neuro ICU physician Peter Reinstrup, MD about these challenges and new opportunities and solutions for simplifying some of the difficulties.

### Can you generally describe some of the challenges and difficulties you have encountered in this situation?

Like many other ICU departments, we struggle with the difficulties in MRI

examination of ventilated ICU patients in certain specific patient categories. Our goal is to maintain ventilation therapy as safely and consistently as possible, to avoid interruptions to therapy in the process of transporting them to the MR department.

We have had patients that we would have liked to examine by means of MR, but if they have high intracranial pressure, caused by meningitis, encephalitis, stroke or trauma, it is important to maintain ventilation with as little disturbance as

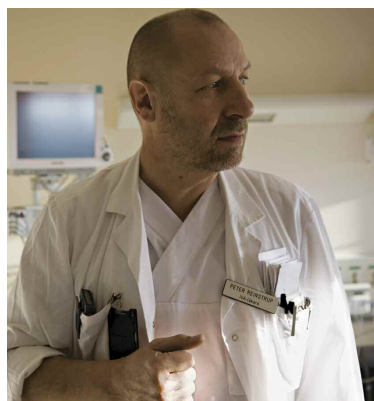
possible. But since this has been extremely difficult to accomplish, we have avoided MR examinations for some of these patients, unless there has been an absolutely acute need for it. The process up to this point involved switching patients to a transport ventilator, and then switching them over to a SERVO 900C in the MR area.

### How frequently do you transport neuro ICU patients to the MR?

The problem in the past has been that it is a very complex process to transport ICU patients to the MR environment, especially ICU patients on ventilators. It is a cumbersome process from a practical and equipment point-of-view. Additionally, there has been the difficulty of providing these patients with correct and adequate ventilation treatment during the transport process from the ICU to the MR department and back again. All of these difficulties have resulted in more CT examinations, instead of MR; about 7-8 patients per week end up going to the CT. Another problem is the staff requirement we have had to transport the ventilated patient to the MR, which means that two nurses and an anesthesiologist must be available. This means that we have limited the MR examination possibility to only very specific patient categories.

### How important are MR examinations here at the University Hospital?

Magnetic resonance imaging is very important to us here in Lund, and we have



Peter Reinstrup, MD, is consultant and Associate Professor at the Department of Anesthesia and Intensive Care of Lund University Hospital.

strategically invested a great deal in this diagnostic technology. Ten years ago, we received one of the first monitoring solutions for MR scanners in Scandinavia, and we now have 4 MR scanners within the University Hospital. It is a strategic area associated with extensive costs, but something that we want to invest in.

Our previous solution for transporting ventilated patients from the neuro ICU to MR was a transport ventilator, and a SERVO 900C in the entrance to the MR room, with extremely long patient tubes. In the very beginning, when we received our first MR scanner in the late 90s, we had two gas tubes outside of the examination room, with the SERVO 900 at a distance, where we stood and calculated compressible volumes and other parameters prior to the examination; to assess how much ventilation the patient would need during the examination. And it worked, but it took a long time. Often these early examinations took the greater portion of a full day with the same patient. At first we only examined anesthetized patients, since we did not have the monitoring equipment necessary, at that time, to monitor ICU patients.

### How will the new solution solve some of these obstacles?

We immediately saw the transport opportunities with the new SERVO-i ventilator, which meant that we could transport the patient from the neuro ICU to the CT or MR department, without interruptions in ventilation therapy. We were also reassured by the fact that the new ventilation platform is developed from the basis of the SERVO 900C, which was a solid platform that we were used to, familiar with and trusted in.

Our experience with the new ventilator in the MRI is that it has worked without any complications, and has simplified the procedure compared to our old system.

### Now when you will have the new ventilator available for ICU patients and MR examinations, how will it work?

We have the same model in the neuro ICU at bedside, which accompanies the patient during transport down to the

MR – ventilation therapy continues without interruption, with the same mode and treatment, so that not even a single breath will be lost, and no patient values will be lost either. We have chosen to have separate SERVO-i ventilators in the MR scanning room. These ventilators are stripped for as much metal as possible and have full battery back up. These precautions have been taken in order to minimize the risk of introducing metal items in the room. During the scanning period, the SERVO-i ventilator runs on battery in order to minimize electromagnetic disturbances influencing the imaging. However, the patient maintains the same quality of ventilatory treatment during the MR examination as he receives bedside in the neuro ICU. And since we all are familiar with SERVO ventilators, including the nurses, we simplify the process. And anything that simplifies the process saves us valuable time.

### Your familiarity with SERVO 900C perhaps stems from the fact that the University Hospital in Lund was a birthplace to SERVO ventilator technology historically.

Yes, the development engineer Sven-Gunnar Olsson worked closely with Lars Nordström, anesthesiologist, and Björn Jonsson, clinical physiologist who both were here in the 70s and 80s. Together, they developed the technology to be able to steer the flow of ventilation to the patient, by means of logical application and ventilatory modes.

### You started working here in 1985, when was the neuro ICU department established here in Lund? How many patients and which types of cases do you care for here on a regular basis?

In the past, we had ventilators in all three neurosurgical departments, and the anesthesiologist coordinated the ventilation treatment. The decision was made to establish a dedicated neuro ICU here at the University Hospital, since it was preferable to consolidate patient care and patient monitoring of the worst cases within one unit. In terms of patient categories, subarachnoidal hemorrhages are a category where we only see about 100 cases per year. We have between 50 to 70 severe neurotrauma cases per year, and



then there are more moderate forms of trauma that need ICU care as well. These patients with acute cerebral trauma can be challenging to treat with mechanical ventilation, as they are prone to develop neurogenic pulmonary edema and myocardial infarction. We also see a broad spectrum of other patient categories: stroke, meningitis, epilepsy, and tumor patients.

We have a total of 16 beds here, six for ICU patients, 4 for intermediate care and 6 post-operative beds. The staffing is in teams which include a registered nurse and a nurse assistant for every two patients in the ICU, 24 hours a day.

**Which ventilatory modes do you most frequently use in the neuro ICU, and how long are the patients on the ventilators?**

Maintaining a constant and steady CO<sub>2</sub> is important in the care of our particular patients. This means that many patients are treated with volume-controlled ventilation, however many of us have a preference for PRVC. Some of our patients are in the ventilator for longer periods of time before they can be weaned, and we usually switch over to Pressure Support in the weaning process.

Usually, patients in the neuro ICU are on ventilators for a period of less than 14 days. We are a highly specialized department, and serve 11 different hospitals throughout the southern peninsula of Sweden, who send us patients for special care and neurological expertise. Sometimes the patients are still on mechanical ventilation when they are sent back to their hospitals at home. Certain categories, such as meningitis patients, can be mechanically ventilated for shorter periods of time, depending on the level of cerebral swelling that occurs as a result of their infection and treatment.

**You and your colleagues are well known for some extensive research, will the new ventilation solution make it easier for you from a research perspective?**

I think so absolutely, we have research projects where we have a special interest within cranial trauma. We would like to conduct more research here, partially based



The University Hospital in Lund was one of the first in Scandinavia to invest in MRI, and currently has four MR scanners within the hospital.



Dr Peter Reinstrup has been treating neuro ICU patients in Lund since 1985, and has conducted research at the university hospital.

on MR examinations that were not previously possible, since it was not optimal from a patient perspective, keeping control of pressures and other parameters.

Variations during ventilation for these types of patients are problematic. This new ventilation solution for MR presents us with an opportunity to measure new modalities like cerebral blood volumes,

where we have measured CBF – cerebral blood flow in the past. With spectroscopy we have opportunities to learn about the chemical changes of the traumatized brain. There are many research opportunities, which have been constrained in the past from a clinical and research perspective, since the ventilatory aspects have been so difficult and limiting.

## Biography

Peter Reinstrup, MD, PhD received his initial medical degree at the University of Copenhagen, Denmark. He received his degree in anesthesiology in Sweden and Denmark in 1987, and obtained his PhD and later became Associate Professor at the University of Lund, Sweden. Early in his career, he served as surgical resident in Lillehammer, Norway, senior anesthesia resident at Skt Elisabeth Hospital in Copenhagen, and senior resident in medical intensive care at the University Hospital of Lund, Sweden. For the past nine years, Peter Reinstrup has been the anesthetic head of the Neurosurgical Intensive Care Unit at Lund University Hospital, and responsible for guidelines for different treatment and introduction of

new equipment for the continuous development of the department.

He has conducted research within the areas of rCBF changes during inhalational anesthesia in collaboration with the Clinical Neurophysiological department of Lund University Hospital, as well as evaluated the neuro-electrophysiological changes due to sedation - anesthesia. Peter Reinstrup has also worked in research of normal and pathophysiologic interstitial biochemical environment in the brain with microdialysis and evaluated its use in the ICU in order to improve cerebral cell survival, as well as evaluated the value of diffusion MRI in brain pathology. He is collaborating with Professor Bertil Romner in establishment and

continued study of transcranial Doppler pulsatility index (PI) for non-invasive measurement of the ICP. Peter Reinstrup has investigated the use of cerebral brain damage markers and measurement of CBV with the SPECT scanner in order to use MRI for the same purpose. He is currently working together with Dr Erik Ryding, Karolinska Institute, Stockholm and Dr Erik Bloomfield of the Mayo Clinic in regard to a new technique to measure continuous global CBF in the ICU.

Peter Reinstrup, MD, PhD has supervised the thesis work of many physicians in Sweden. He has also acted as referee for many publications, including *Anesthesiology*, *British Journal of Anaesthesia*, *Acta Anaesth Scand*, and *Pharmacology & Toxicology*.

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NICU staff members Sabrina Sanchez, RN, NICU chief physician Alice D'Agostini Deutsch, Felipe de Souza Rossi, MD, Thalita de Paulo Low, RN, Celso Rebello, MD, PhD, and Maria Fernanda P S Dornaus, RN.

## Evolving ventilatory strategies for premature infants

The Albert Einstein Jewish Hospital of Sao Paulo is one of the largest and most prominent hospitals in Latin America, and is in fact the first institution outside of the United States that was certified by the Joint Commission International.

Founded in 1955, the hospital has provided a neonatal intensive care unit almost from the start, and with the new NICU inaugurated in 2000, it is one of the most modern in Latin America.

Critical Care News met with Dr Celso Rebello, who has conducted research in surfactant and mechanical ventilation in premature babies in Brazil and in the United States. He shared his experiences and ideas about new strategies for protecting the underdeveloped lung.



**Can you tell us a little about your background, and describe the NICU facility here at Albert Einstein Jewish Hospital?**

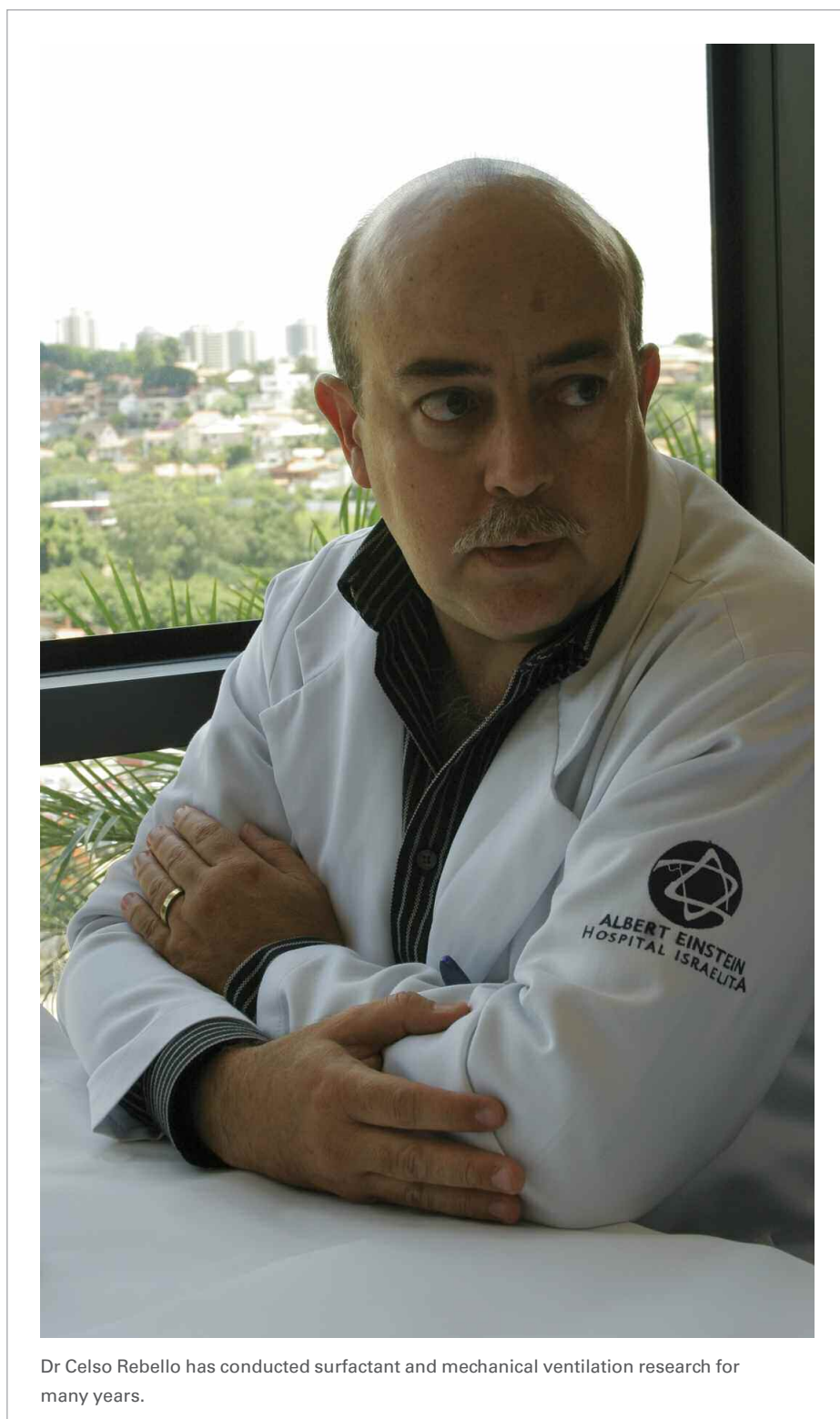
My background of research is clinical research made here in Sao Paulo, at the Department of Pediatrics of Sao Paulo University, but I also spent two years at the University of California. I have been working with mechanical ventilation and surfactant research for many years now. My colleagues and I are especially interested in the developing lung, and the problems related to it. We have developed, in cooperation with the Butantan Institute, a new method of pulmonary surfactant extraction. This new surfactant derived from minced pig lungs was tested in our laboratory and we are now conducting a clinical trial comparing this new surfactant with a commercially available one.

We have capacity to care for 12 preterm infants in the NICU, and 10 infants in the NICU intermediate care unit. The unit has a total of 20 physicians, and in the NICU we have one nurse to every patient. If the baby is very sick, for instance after cardiac surgery, we maintain two nurses to each baby. Our nursing ratio is 1 nurse to every 2 patients in the intermediate care unit. We care for babies ranging in gestational age from 24 weeks until term, but our average patient is between 27-29 weeks of gestation. We get a lot of multiple births, and we see smaller babies in these cases.

**What is the most frequent type of patient situation that you encounter?**

Our most frequent situation is respiratory distress due to lung immaturity. We do not frequently see babies with malformations as we see in academic hospitals, but mainly very small preterm babies with underdeveloped lungs and respiratory distress.

We welcome parents to be with the babies 24 hours a day. There is a special room for the parents next to the NICU where the parents may rest; we have a comfortable chair next to each baby in the NICU, in order to maintain close proximity between the babies and their parents. We train the staff to instruct the parents, and



Dr Celso Rebello has conducted surfactant and mechanical ventilation research for many years.

as soon as the clinical situation allows, we try to keep the baby in close body contact with the parents as much as we can. We encourage this close contact, since it is good for the father, mother and the baby, it makes the parents more confident about the development of their child, and prepares them for the day when they can go home together.

**What is the average length of NICU stay for each baby?**

Depending on the gestational age, they usually go home at about 35-36 weeks gestation. In cases with complications, the length of stay may be longer. This is a very important hospital center in Brazil, so it is not unusual to receive patients from

other parts of our country, and other countries in South America as well. We receive patients that come to Sao Paulo to receive health care here. In some cases, the baby is born in another part of the country, and he is transported to our NICU, depending on the clinical situation.

### When did you originally start working with nasal CPAP therapy?

Actually, for as long as I have been working as a neonatologist. I became familiar with nasal CPAP from the beginning of my career, over 23 years ago. In the early years, CPAP was very difficult to apply because of the lack of proper prongs for our patients. When we got better interfaces, it was possible to use it more frequently. And the idea now is to use nasal CPAP more frequently than invasive mechanical ventilation whenever possible. We want to reduce the risk of lung damage, and successful nasal CPAP therapy means that you can minimize lung damage in preterm infants. With the new SERVO-i device with nasal CPAP technique, we saw the opportunity of a comparative study between our routine equipment and the SERVO-i device.

### What are the most important practical factors when providing nasal CPAP? Is it the application or the patient interface?

In my opinion, it is a combination of different important factors. You must have the correct interface, because if it does not fit properly, you will have problems. You must have good equipment, in order to deliver nasal CPAP properly. You must have a very well trained and motivated team, which is probably the more important aspect. This means thorough



NICU patient at Albert Einstein Jewish Hospital.

bedside baby monitoring, to make sure that you will know if the nasal CPAP is not working, and go through a checklist, like airway secretions that can be easily solved, head or prong position, and other technical aspects. You must have the right interface, the right equipment, and a motivated team working with you, especially nurses, that have the same objectives and understanding, 24 hours a day, to be sure that the device that you are using is being applied in the proper manner.

### What in your opinion is the indication for nasal CPAP therapy?

I think that nasal CPAP therapy should be used for any patient needing lung protective ventilation. I believe that invasive mechanical ventilation should only be used when nasal CPAP is not feasible. The primary indication for nasal CPAP therapy, in my opinion, is to treat respiratory distress. If you can give the preterm baby functional residual capacity, and open up the alveoli and keep them open, you can wait until the production of surfactant becomes normal, within two or three days of life, avoiding intubation and mechanical ventilation. Thinking about bronchopulmonary dysplasia, this is the best approach to treat respiratory distress in the preterm baby. The main problem is that if you want to use nasal CPAP therapy, you must use it right, which means the right technique, right patient and the right interface. We are working to improve the techniques and figure out what is the best device to apply nasal CPAP that we can use. If we do not use the right technique, device or interface, we are probably using more intubation and mechanical ventilation and increasing the risk of lung damage. The international

literature shows clearly that if you use nasal CPAP in the correct way, you can reduce the incidence of bronchopulmonary dysplasia in very low weight preterm babies, which is the population more exposed to this complication.

Dr. Wong from Columbia University has visited us recently. He has conducted many studies about CPAP therapy, and he and his group demonstrated that if it is done with the correct technique, it is possible to treat very preterm babies, from 24 or 25 weeks of gestation, with nasal CPAP. The group from Colombia has showed that this is possible. But it must be done in the right way, in order to have success.

### Do you make Y-piece measurements?

Yes, I strongly prefer the Y-sensor for monitoring respiratory mechanics, because in my laboratory we can see clearly that, for the small preterm baby, when you do the respiratory mechanics measurements close to the endotracheal tube you have fewer mistakes and fewer errors in the numbers. The pneumotachs that most equipment uses have a wide range of use, from the preterm baby to the adult. We are talking about a range from 600 g to 80 kg of body weight. Therefore, the very preterm baby is almost out of the range of these pneumotachs. If you use a Y-piece sensor you can reduce this error, first because you can use a pneumotach more accurate for neonatal use, and secondly because you don't have to compensate the compliance of the system of the patient tubes. For a patient with 600 grams of body weight, to deliver a tidal volume of 6 or 7 ml per kilo means only 3 ml or 4 ml. Therefore, a 1 ml mistake means a lot and has consequences. If you want to do the monitoring of the respiratory mechanics, you must obtain precise measurements.

**You have conventional nasal CPAP devices and you started using SERVO-i with nasal CPAP therapy about a year ago. In infants who are intubated and mechanically ventilated, who later receive nasal CPAP therapy, have you observed that the incidence of re-intubation after using nasal CPAP is lower?**



Dr Arno Warth with patient.





The Albert Einstein Jewish Hospital in Sao Paulo is one of the largest hospital institutions in Brazil.

Yes, we have observed this but we do not have the numbers yet. This is the motivation to start the comparative study, only then will we be able to publish the data that hopefully will confirm our impression. We have a personal feeling that the SERVO-i nasal CPAP therapy gives us a better result, but we have to go from personal impressions to measured results.

**Can you tell us more about your planned clinical study, comparing nasal CPAP therapy with conventional CPAP devices, and nasal CPAP therapy with the SERVO-i ventilator?**

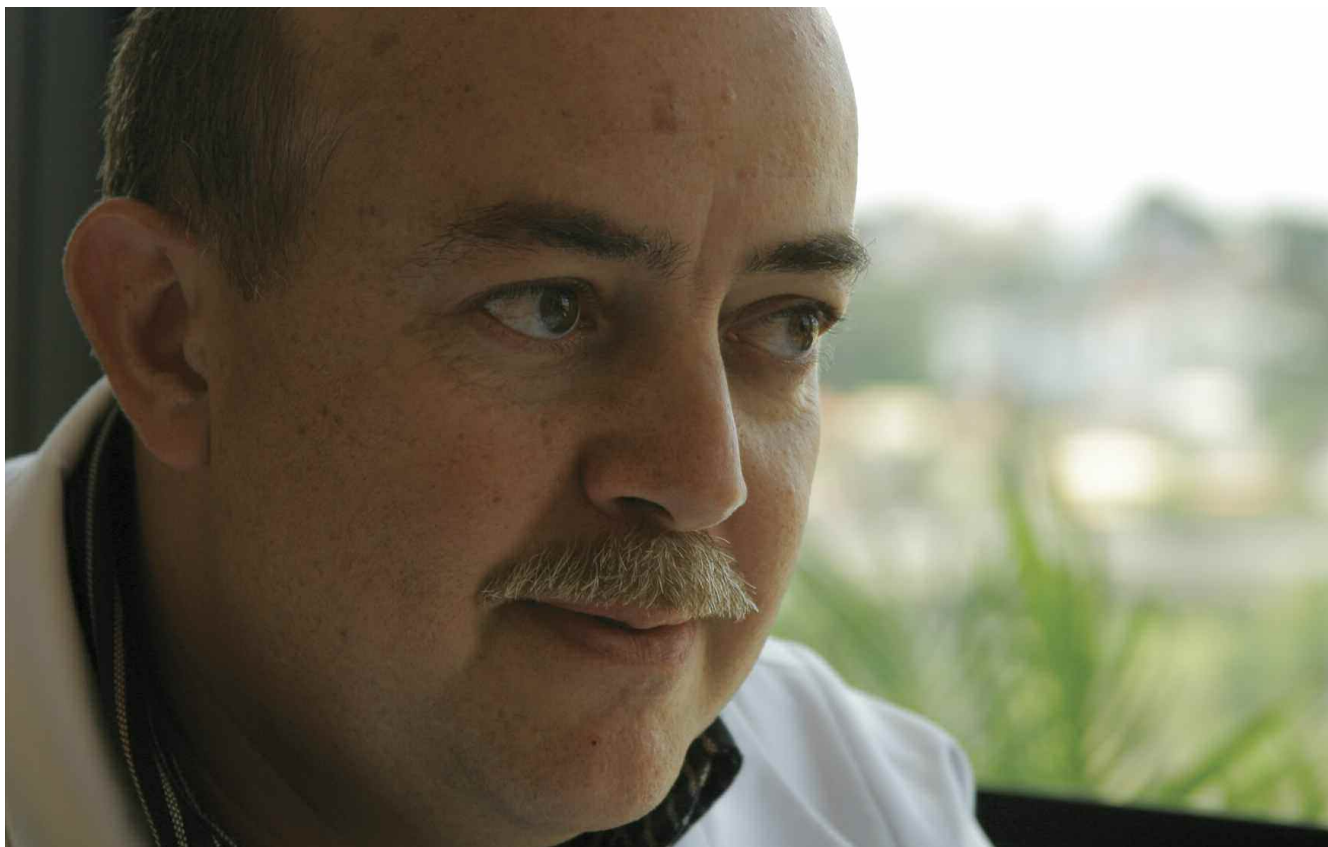
This study is part of our research in mechanical ventilation here in the Albert Einstein Jewish Hospital. The background is the idea of using more frequently nasal CPAP aiming to reduce lung damage caused by mechanical ventilation. We are especially interested in the opportunity to compare the efficiency of the conventional CPAP therapy, with the nasal CPAP provided by the SERVO-i ventilator, in order to increase our success with nasal CPAP therapy. The improvement in the technique to apply nasal CPAP can reduce the incidence of intubation and mechanical ventilation, reducing the risk of lung damage in preterm babies. We

believe that the control of leakage and adjustment of airway flow provides a more efficient delivery of nasal CPAP, with better results. In our opinion with SERVO-i nasal CPAP therapy we can achieve better results compared to the conventional nasal CPAP devices.

**How many patients are you intending to include in this study?**

The estimated sample size is 30 patients for each study arm, which means approximately one year of study, to establish a statistically significant difference regarding to the rates of intubation.





Celso Rebello, MD, PhD.

**Is there an advantage to using one ventilator that can provide invasive mechanical ventilation together with nasal CPAP therapy?**

Absolutely. Having one device that can provide both therapies is cost saving for the hospital. If a patient using nasal CPAP therapy does not improve and needs invasive mechanical ventilation, it is an advantage also for him if the same ventilator can be used. Also when the preterm baby is improving his lung function, it is an advantage for him and for the hospital if you do not have to remove the ventilator in order to apply another device for CPAP therapy, this consumes staff's time and is disturbing for the patient. It is also an advantage for the staff to not have to be familiar with more devices than necessary.

**What is important when training the staff with the ventilator that combines conventional mechanical ventilation with nasal CPAP?**

All the staff should be familiar with the equipment. In our country, the physician and the nurse must be very familiar with how the ventilator works; not only with the equipment but also how it improves the respiratory function regarding any particular patient or disease. When the staff fully understands how the equipment works, and the objectives of the respiratory therapy, the motivation to perform a better level of quality of respiratory care is achieved. The best way is to maintain that the people around the baby are motivated so every alarm, every single button and parameter is understood, not only from the technical aspect but also regarding the progress of the therapy. Only in this way can the situation be evaluated for each baby, and the therapy adjusted when needed. Training and motivation go together.

**Nebulization is an important factor in treating preterm infants; can you tell us about your situation?**

We currently use conventional nebulizers, but this is in the process of change. We need to define which nebulization equipment will be used in our comparative study of conventional nasal CPAP devices and SERVO-i nasal CPAP therapy.

**Can you tell us about other future research opportunities that you are interested in?**

Our primary interest is how to reduce lung damage in the preterm lung. We need more tools to determine how much pressure should be used, and to evaluate how effective the mechanical ventilation therapy is. The precise determination of the lung compliance and volume is important, but does not necessarily correlate to all sections of the lung. Electrical Impedance Tomography (EIT) is a tool that we believe can give us a better understanding of how to use pressures and how to use volume in the ventilator. It complements what we have currently, which is lung mechanics. We intend to

start a study using EIT in the coming months. The goal of this study is to decide, when extubating the baby, which pressure should be given by nasal CPAP to keep the lungs open. We think that EIT could be a very practical tool at bedside to obtain this information. One arm of this study will use EIT to determine the best pressure to keep the lung open, the other arm is the regular extubation process that we usually use, which is nasal CPAP of 5 cm of H<sub>2</sub>O. We strongly believe that when you determine the pressure that provides a better FRC, the result of the extubation will be improved. This is the first time that this is being studied in preterm babies, here in Brazil. We are aware of another group studying Electrical Impedance Tomography for preterm babies in Europe; and we think that it can be a very useful

tool for mechanical ventilation in preterm infants in the future. With good ventilators, good means of evaluating respiratory mechanics and lung gas distribution, we can manage the ventilator in a better way in order to reduce the risk of lung injury.

In this project we are working in collaboration with the group headed by Dr Marcelo Amato, who developed this EIT equipment for use with adult patients. The underdeveloped lung and the possible complications of the preterm baby make them totally different from the adult. Therefore it is a new patient category for EIT, with a new approach and new solutions. We are working with Dr Amato's team in order to adapt the EIT for use in preterm infants.

## Biography

Celso Rebello, MD, PhD, studied intensive care medicine and received his medical degree at Sao Paulo University Medical School, in 1983. He has conducted research within the areas of surfactant therapy and mechanical ventilation, at the University of California as well as the Department of Pediatrics of Sao Paulo University Hospital.

He is currently involved in research projects at the Department of Pediatrics of Sao Paulo University, as well as at the Albert Einstein Jewish Hospital of Sao Paulo, where he has been working in the neonatal intensive care unit since 2000.

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