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MAQUET

Critical Care News

Theme:

Clinical application of NAVA – the ICU team perspective

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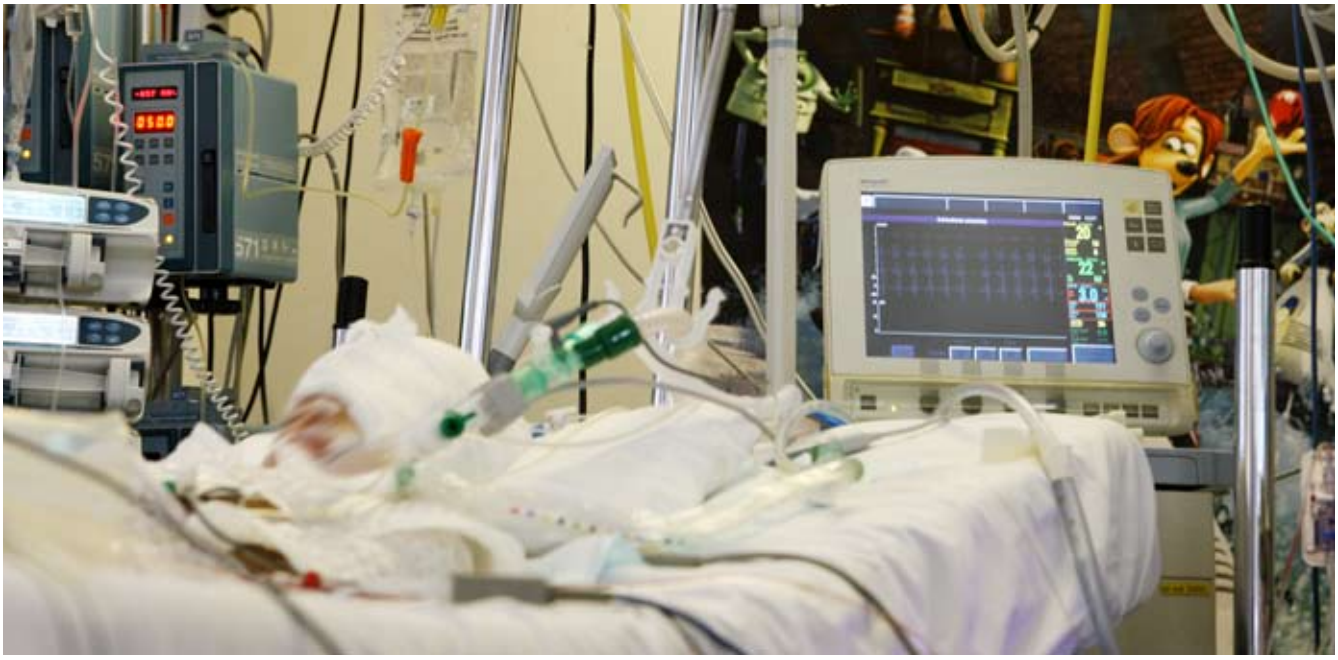

Pediatric trauma patient treated with NAVA at the PICU of the University Hospital of Brussels. A case report for this patient may be found on www.criticalcarenews.com

Expanding strategies, opportunities and experience in ventilation therapy

As a peer-to-peer magazine, Critical Care News strives to document the current experiences of intensive care clinicians within ventilation therapy, so that these may be shared from one ICU to many others around the world. In this respect, the magazine may also be considered as a "mirror" for what intensive care physicians, caregivers and researchers are focusing on at this moment in time, in terms of clinical application of ventilation modes.

The use of Neurally Adjusted Ventilatory Assist, or NAVA, as a mode of ventilation has been reported in many interviews and articles in the magazine. The concept of NAVA was first featured 2006 in Critical Care News (issue no. 12) and the first impressions and clinical application experiences were reported in issues 13 and 14, followed by broader experiences in series of patients in issues 15 and 16. In the reportage entitled "NAVA – past, present and future perceptions" from the Department of Intensive Care at the Ospedale Maggiore della Carità in Novara, Italy, the experience from the clinical evaluation of NAVA was reported. It may be interesting to note that one year later, the research of this group has led to the publication of a randomized controlled trial of 14 patients, entitled "Physiologic response to varying levels of pressure support and neurally adjusted ventilatory assist in patients with acute respiratory failure" (D Colombo et al, Intensive Care Med DOI 10.1007/s00134-008-1215-4) as well as an editorial in the same publication by Franco Laghi entitled "NAVA: brain over machine?" (Intensive Care Med DOI: 10.1007/s00134-008-1208-3.)

The continuing evolution of physician experience with NAVA in specific patient categories as well as patient case reports is the primary focus of this issue of Critical Care News. These categories include adult, pediatric and infant patients and are reported from physicians at three different intensive care units around the globe.

In addition to NAVA, expanding treatment opportunities for ventilation care of infants in fixed wing aircraft are also reported.

Clinical application of NAVA – the ICU team perspective

The entire staff of the Pediatric Intensive Care Unit of the University Hospital of Brussels has been trained and is actively using Neurally Adjusted Ventilatory Assist - NAVA.

After initial experience with NAVA in weaning for uncomplicated patient cases, Professor Saïd Hachimi-Idrissi and staff members became interested in gaining experience with NAVA in more complex cases. Professor Idrissi and clinical nurse specialist Dirk Danschutter share their experiences of these complex cases with Critical Care News, and have contributed patient case reports to the magazine website, www.criticalcarenews.com

Thomas Similowski, MD, PhD, in the ICU of Pitié-Salpêtrière Hospital in Paris.

NAVA – translating research into clinical practice

The ICU of the Department of Respiratory Medicine and Intensive Care of the Pitié-Salpêtrière Hospital in Paris have a particular focus on cerebral cortex activation, control of the diaphragm, and variability and chaos in connection with mechanical ventilation, in research as well as at bedside.

Thomas Similowski, MD, PhD, Head of the Department of Respiratory Medicine and Intensive Care at Pitié-Salpêtrière as well as head of the Respiratory Pathophysiology Laboratory and ICU physician Dr Alexandre Demoule share their early observations of NAVA as well as their research interest in the area of neural control of breathing.

Zhu Limin, MD, in the CICU at Shanghai Children's Medical Center.

NAVA in the post-operative treatment of congenital heart disease infants in China

The latest advancement with the Department of Cardiovascular Thoracic Surgery at the Shanghai Children's Medical Center is the implementation of NAVA in post-operative treatment of infants undergoing congenital heart surgery.

CICU Chief Dr Shi Zhenying and Dr Zhu Limin with colleagues have recently gained a rapidly expanding experience of Edi monitoring and NAVA as a treatment modality in this patient category. They highlight these experiences, as well as use of esophageal ECG as a diagnostic tool in the magazine interview, and have contributed a patient case report to the magazine website, www.criticalcarenews.com

Aircraft from the Swedish Air Ambulance fleet.

Ventilating infants in critical care air transports

A close collaboration between the Swedish Air Ambulance company (Svensk Flygambulans AB) and the PETS team (Pediatric Emergency Transport Service) from the Astrid Lindgren Children's Hospital at the Karolinska Hospital in Stockholm, Sweden, led to integrated technological solutions to provide bedside quality ventilatory support to infants transported in fixed wing aircraft.

Critical Care News met with team members of this collaborative effort from both groups to hear how the transport solutions were developed, and to understand their experiences with air transport of over 40 critically ill infants during the past two years.

ARDS – Pathophysiology, Detection and Therapy, a symposium summary report

The final feature of this issue highlights the seventh and latest MAQUET symposium which recently took place in Prague, Czech Republic. Critical care delegates from over 20 countries attended to hear the latest findings in regard to ARDS, acute lung injury and NAVA.

The symposium was chaired by Professor A S Slutsky of the University of Toronto and St. Michael's Hospital, Toronto, and featured a distinguished panel of internationally known speakers. Each presentation was followed by panel discussions, with interactive exchanges between faculty and participants.

Professor Saïd Hachimi-Idrissi with pediatric intensive care patient.

Clinical application of NAVA – the ICU team perspective

The University Hospital of Brussels – Jette (Universitair Ziekenhuis Brussel) is located in a quiet area next to a beautiful park only 10 minutes from the center of the city. The basic principle of the hospital is that high-quality medicine should be accessible for everyone, with as few financial barriers as possible. With more than 700 beds, the UZ Brussels handles more than 25,000 admissions every year. As a university hospital, UZ Brussels has an educational focus and conducts scientific research, and has established the hospital reputation as a top player, with national and international recognition.

The Pediatric Intensive Care Unit of the University Hospital of Brussels has a long and well established reputation as pioneer in the research and clinical application of lung protective ventilation. The PICU was early to study and adapt Pressure Regulated Volume Control - PRVC and Automode in the 1990's. The entire PICU staff has been trained and is using Neurally Adjusted Ventilatory Assist – NAVA for the past four months. After a few initial experiences in weaning for uncomplicated patient cases, Professor Saïd Hachimi-Idrissi and staff have been gaining experience with NAVA in more complex cases. Professor Idrissi and clinical nurse specialist Dirk Danschutter shared their experiences with Critical Care News.

When did the PICU staff first become familiar with the concept of NAVA?

Professor Idrissi: We wanted to start experiencing NAVA as soon as the CE mark was available. Our research background and profile means that we are curious, want to learn, and need to be challenged. Any new thing that may help the outcome of our patients, we want to try. I have a background working in research with neurotrauma, cardiac arrest and brain damage, and I see NAVA as a chance to move from the clinical setting to the pathophysiological mechanics. That is why we are interested in gaining experience with NAVA, not only to improve the cerebral outcome, but to allow us to go into the pathophysiological approach to ventilation. It is quite surprising, as it is a completely different way of working compared to all the conventional means of ventilation in the past.

With a research background in neurotrauma and cardiac arrest, Professor Idrissi has been interested in gaining experience with NAVA in more challenging clinical situations.

What are the advantages of being early "ambassadors" of a new method of ventilation, and why are you interested in gaining experience in more complex situations?

Professor Idrissi: More than 20 years ago, Pressure Control and Pressure Support modes were new, and it has taken time for the ICU community to accept them and adapt them, but they are regarded as standard today. It was the same process for CPAP when that method of ventilation was first introduced. We also observed this same process of learning, acceptance and implementation with high frequency ventilation. NAVA is just starting out, but we want to learn more about NAVA in the challenging cases, where we have the potential to learn the most. After a few initial cases, I realized that I was not interested in using NAVA in "easy" situations, like weaning or straightforward cases, where I already know what the outcome will be. I wanted to start NAVA in complex cases, as this will challenge us to understand what is really happening from a physiological perspective. In easy cases, those patients are not in need of complex ventilation and I know of the outcome beforehand. The problem is we need to have more complicated cases and experience with NAVA in order to understand what is really happening. To go into the pathophysiology of the neural triggering and the oxygenation process, this is important for us to learn and know.

Can you describe the primary factors and process leading to the decision to investigate and implement NAVA in this ICU? When did you have your first patient experience with NAVA and how did you prepare for that as a team?

Dirk Danschutter: Before we started using NAVA, we invited the MAQUET representative to conduct training and education in small groups or teams. We have 15 nurses that needed training, and we trained them in groups of 3 or 4 at a time, with the educational materials that are available, in order to illustrate the concept, application and process to them. The intensive care physicians had training with a similar process. All of the nurses and doctors received this training; the entire PICU staff was involved. In the beginning for each NAVA patient, we had about 4 or 5 people involved as teams for the next 4 or 5 days, with a supervising physician in attendance.

What in your opinion is the advantage or benefit of Edi monitoring as a bedside parameter?

Professor Idrissi: We insert the Edi catheter, and monitor the signal, as it provides us with important information. There may be no Edi signal initially, if the patient is deeply sedated and the diaphragmatic muscle is suppressed by the sedation. We have started to understand more about what the Edi signal is, and we have started to see what is really happening. If we have a decreased signal, maybe we need to reduce the ventilation. We have been using and observing the Edi signal in conventional ventilation modes; in order to understand the characteristics and the behavior of the diaphragmatic

activity in conventional modes. This helps us to adjust the ventilation accordingly, and to focus on the blood gases. It is a new way of thinking and a complement in monitoring, compared to what we have had in the past.

Do you see the Edi signal as a means of seeing how the patient is coming out of sedation, in the washout period?

Professor Idrissi: Absolutely, we were quite surprised by following the screen step by step, and we have found by the Edi signal that the patient was trying to breathe, but that the settings of the ventilator did not allow him to breathe. This is important for us to learn; as physicians we want fixed values, heart rate, blood pressure, frequency and so on. But in the reality we have a lot of variability going on, according to type, the disease process, the condition of the child, etc. In the pediatric situation, this is especially complex as children are different ages, weights and in different stages of the growth process. I think it will be easier for us to implement NAVA in adults in our hospital, since we are starting to gain experience in more complex situations, and in children, who are a more dynamic patient population.

What is your general experience in regard to patient response to NAVA?

Professor Idrissi: My initial experience was when we started with the first 3-4 patients who had been ventilated by conventional mechanical ventilation for several days. My first impressions of NAVA were to try it for weaning purposes. We were quite rapidly convinced that the transitions of those patients from conventional mechanical ventilation to neural spontaneous breathing was that they were doing well, breathing without any stress, and we were able to reduce the sedation quite rapidly in those cases. The weaning process was quite easy, compared to the way we were doing it before, which was weaning and seeing what happened in the next 3 days, and a few had to be reintubated and sedated and go back on the ventilator.

Dirk Danschutter: We soon also got the impression in those first patients that we had to start implementing NAVA much earlier, in fact as soon as the patients were intubated.

Dirk Danschutter, clinical nurse specialist

Professor Idrissi: We are realizing that as soon as the patient needs ventilation, for whatever reason, and for us there are many children with respiratory distress syndrome, that we can start NAVA earlier in the process. Our small patients have to be sedated in order to initiate ventilation. In those patients that have to be sedated to be intubated first, we want to start the NAVA as soon as the sedation allows, in order to let them recruit in the way they want, to obtain the frequency levels that they want, to allow them to receive the pressures that they want, and the only parameter we need to know is the NAVA level that is appropriate for that patient, without any stress, with higher levels to give more assist and unloading, and lower levels in cases where the patient wishes to actively use their diaphragm more. This is the way we are moving forward, with NAVA much earlier in the process.

It will be interesting when the bronchiolitis season starts this autumn. Patients often have to be put in non-invasive ventilation or CPAP, and if those patients are not doing well, they will need to be intubated. I think we will sedate those patients to start mechanical ventilation and reduce the conventional ventilation by monitoring the Edi signals, and start them on NAVA to see what happens. In these patients, the airway is secure, and they will be able to ventilate themselves according to their neural drive, and I think that NAVA will help them, in a much more physiological manner, than we have been able to provide with conventional modes in the past.

In this respect, it is important to stress the physiological aspect: an average lifespan is 80 years – which means that for 80 years we will be continuously using our muscles and diaphragm to breathe. It is completely converse that we must immobilize all of these muscles in conventional mechanical ventilation for a period of time, as we have been doing for the past 30 years. This is what intrigues me. Our colleagues are focusing on lung injuries, and lung protection in mechanical ventilation, and the values in this respect in mechanical ventilation. In NAVA we observe patients that are neurally using 6 or 7 ml per kilo, and this indicates that our own physiological and neural systems naturally know what levels of volumes and pressures are best for us. We need to allow the patients to adapt to their volume, pressure and frequency levels that their neural systems direct, instead of us physicians determining these levels. We need to supervise and help our patients, but we need to allow our patients to "treat" themselves.

Are there some specific patient experiences where you received results that you did not necessarily expect with NAVA?

Dirk Danschutter: In two patients I saw something intriguing, when they are coming out of deep sedation, that as a nurse, I am not certain if the diaphragm is the first respiratory muscle to respond. We have seen other triggering, perhaps from the other respiratory muscles. It was an interesting observation in

Professor Idrissi with PICU staff member Dr Willemijn Van Heel.

a couple of cases. It is an intriguing observation that would be interesting to see as we see larger groups of patient populations. I am also interested in seeing if other muscles are creating negative pressures captured by the system, other than the diaphragm. I am interested in seeing the cascade, in which respiratory muscles respond first in the sedation washout process.

Which patient categories are those that you have gained the most experience of NAVA with?

Professor Idrissi: The experience so far is mainly in pediatric patients with respiratory insufficiency, often due to cardiac arrest, and in many respiratory problems. Most of the patients we have treated so far have been infants, but some have been 3 or 4 years of age.

We had one case with a child who achieved return of spontaneous circulation after cardiopulmonary arrest secondary to encephalitis of the brain stem. When we started out, we knew that the child had encephalitis, and when the patient condition usually stabilizes, in terms of hemodynamic and cardiac output. We started to monitor the Edi signal on a conventional mode of mechanical ventilation. We were quite surprised to find no movement of the Edi signal. We were asking a lot of questions, if the lack of diaphragm activity was due to sedation problems, or technical problems with the Edi catheter or the ventilator, but after 1 or 2 days we still did not see any Edi. We realized that this patient had no diaphragmatic movement at all, so the child was evaluated in the MRI and we found that the encephalitis was affecting the cells of the brain stem, or the breathing center. This confirmed to us why we were not picking up a diaphragmatic signal, as the breathing center in the brain was affected by the encephalitis. In other types of encephalitis, for example cortical encephalitis, we do see some forms of breathing, but in this case, the lack of the Edi signal was an early physiological indicator that this child was essentially brain dead secondary to a longer period of cardiac arrest prior resuscitation.

In general, our patient category ratio is about 60/40 for medical and surgical cases on average, and we have experience with NAVA from both groups. The problem is that the surgical patients are ventilated for a short period of time, or the so called "easy cases" and are not compromised from a respiratory standpoint. However, these are the cases where we can recommend other ICUs perhaps to start out with, to gain experience with NAVA if they have never used it before. The non-complex surgical cases might be appropriate for those that want to start with NAVA, to see the behavior of the Edi signal in sedation and in conventional mechanical ventilation, and switching to NAVA when the sedation levels start to reduce. However, at our ICU we have moved on to more complex cases. We find that we do not learn as much about NAVA in these easier cases, as in some of the more complex medical situations.

Another interesting patient case was in relation to high frequency ventilation. We have a physiotherapy nurse who does a lot of high frequency ventilation during physiotherapy, in order to facilitate lung drainage. In this particular case, we had had a very nice Edi signal, the patient was doing well, and when we started high frequency ventilation and physiotherapy, the Edi signal disappeared completely. It was as if the diaphragm was stunned. The only explanation I can see is if the patient is hyperventilating, and the CO_2 is very low, the patient physiologically stops breathing. Our trigger is CO_2 monitoring, not oxygen monitoring. Maybe when we start doing the high frequency and hyperventilating for a short period of time, there is a drop in CO_2 and the patient's brain had decided to stop breathing and signaled to the diaphragm to stop contracting. The physiotherapist became quite anxious, as we are becoming familiar with the Edi as a new monitoring device, and we had a good signal that suddenly disappeared with the high frequency. The child was doing well, and after a while the Edi signal reappeared. Maybe that we need to think about doing some blood gas analysis to see what happened during that short period of time. I think also that one other explanation is that with high pressure and the patient's diaphragm was overextended on the high frequency, this might lead to the suppression of the diaphragmatic contractions and disappearance of the Edi signal. This is intriguing as an observational aspect, and we are interested in learning more and following this up as we go forward.

What is the most complex patient situation that you have treated with NAVA so far?

Professor Idrissi: The most complex patient experience with NAVA was one of the most difficult patients we have had. She was 3 years old, had high frequency ventilation with a high pressure, treated with nitric oxide, with several thorax drains. It was quite surprising to see that against all the things we knew so far about mechanical ventilation, sometimes we have been obliged to increase the PIP up to 50 cm H_2O in order to have an oxygenation. It was difficult to oxygenate this patient for many reasons: ARDS, infection, pneumothorax, and practically any complication you can get, we experienced with this child. She had been on mechanical ventilation for 4 weeks. The big problem was in sedating this child. She had a cocktail of medications, and after a time she would become used to these drugs and start breathing, and fighting the ventilator and desaturating. In time, we were despairing of how to sedate the child in order to keep her on ventilation, with high oxygenation, high pressures, high CO_2 and so on. The lungs were weak and rigid, with oxygenation and pressure problems, emphysema, in order to save the child, we were even thinking about lung transplantation. We thought we would try NAVA to see what would happen. We monitored the Edi signal, and we were quite surprised to see how well she did after switching to NAVA. Within 1 or 2 hours, she started to stabilize, and we finally were able to wean this patient from the ventilator.

She was a nightmare for all of the ICU staff, but we put her on NAVA, against all concepts of conventional ventilation, and she did well. Her neural response led to the pressures being reduced, and her oxygenation levels stabilized, and we were finally able to extubate her after one week on NAVA. We were all amazed. In evaluating this case afterwards, one of the explanations for the situation is that we feel we were requiring the child to have a strict ventilatory frequency, a strict tidal volume a strict PIP, a strict PEEP, according to conventional ventilation. Sometimes the child needed higher pressures, or lower tidal volumes, and once we put her in control with NAVA she started to improve.

How is the ICU team handling continuing education in the use of NAVA as you are gaining experience?

Dirk Danschutter: All the PICU staff members have received initial training on NAVA, and everyone has access to intranet. The intranet access means that any staff member can go back to the on-line materials and refresh if they have not done NAVA recently.

We have also developed informational material on NAVA for the parents of our patients, along with the other educational materials that we provide to them. This familiarizes them with the process for the Edi catheter and the ventilator screens, and this familiarity makes them more comfortable. The parents' involvement is important, and we consider the parents part of the team approach around the patient.

Who within the PICU is responsible for insertion of the Edi catheter and placement verification and use of the Edi catheter?

Dirk Danschutter: The nursing staff place and insert the Edi catheter. We calculate the placement and NEX measurements - the distance is measured from the bridge of the nose (N) via the earlobe (E) to the Xiphoid (X), and after insertion we verify with the ECG leads in the central position and the P-waves on the ventilator screen. We use the NAVA preview screen in Edi catheter placement. We usually verify the placement with the physicians, so that they also see that the Edi catheter is in the correct position in relation to the diaphragm.

Professor Idrissi: This is why it is important to have the staff involved and part of a team effort. In the very first couple of NAVA patients, the physicians placed the Edi catheters since the technology was new for us, but the nurses are used to placing the ordinary nasogastric catheters, and indeed all catheters outside of the central lines, so it seemed quite natural for us that the nurses should be responsible for this part of the process with the children, and it works very well. We have never had any need as physicians to be involved in this process, and the nurses may also detect if there is any difference in signal quality in time or after a few days, they may see how positioning the patient might be affecting the signal. For me it is very important, that we are working as a team, and I will never do anything without my nurses understanding what the effort or goal is. We also get valuable feedback from the nurses, who are involved in the patient care. The nurses and physicians work toward the same effort and goal, and everyone is informed and involved as a team.

It is important to have the nurses behind us. I remember when we started doing hypothermia for cardiac arrest in adult patients, at one point I was questioned by a nurse as to why the patient was still normothermic, while he should be hypothermic, and this was before the implementation of hypothermia as guidelines in patients regaining heart beating after cardiac arrest. That means, when the staff nurse is aware of the potential benefits of one treatment, they accepted it and even encourage it. If we achieved the same approach with NAVA, that means that this technique is beneficial to our patients and well accepted by the staff. We need to better categorize the patients, which should be put on NAVA and which should not. This is the next stage of the process.

What is the average amount of days that the Edi catheter is used for NAVA, Edi monitoring, and feeding?

Professor Idrissi: For the moment we are not really using it for a feeding tube, but I think it is the ultimate goal to combine these two functions. The Edi is only regarded for detection by the nurses. I don't see any problems with the Edi and the feeding. The Edi catheter is in each patient 7 or 8 days, on average. We have had no difficulties with signal quality or any other aspect.

Do you frequently change NAVA level settings? If so, how large intervals are used when the NAVA level is changed?

Professor Idrissi: One of the things the nurses dislike about me is that I don't

Dirk Danschutter designed the mobile ICU system with SERVO ventilator. Over one-third of the PICU patients are sent to UZB from referring hospitals.

like to strictly follow protocols. I saw that when we started working with the children with IRDS. Each time you follow the patient condition and you make a change, you need to document it. Since I am in the learning and experience phase with NAVA, I am quite often changing the NAVA level on a patient by patient basis. We start out, in general, at a certain NAVA level; but prior to that we start with Pressure Control or Pressure Support and monitor the Edi signal. Before starting NAVA, we increase the level of the NAVA in order to have a concordant situation in the beginning. Then we decrease according the patient's need. In our very first NAVA patient, it was a difficult situation. A neonate with bronchopulmonary dysplasia and cardiac arrest, we were unsure of his neurological status, so we started with a low NAVA level, and we saw that the patient had some difficulties to breathe. I think that after three hours we switched to conventional ventilation. A day later, we started on a higher NAVA level, and the patient was doing well, with more unloading of the diaphragm, which seemed to help the patient. When I started on Pressure Control, I picked up the Edi signal, observed the pressure/volume curve, and tried to simulate this with the NAVA level to get the same condition, which is the NAVA level we start out with. This is our general process in determining the NAVA level. Frequently, after one or two hours I might decrease the NAVA level as the patient diaphragm activity and strength permits.

How is monitoring of the Edi signal in conventional ventilatory modes or in stand-by useful?

Professor Idrissi: This is a completely different way of treating and helping the patient. I think that while using NAVA, we need to free our mind from the concept of the conventional ventilation. It is indeed a new concept and a new way of thinking, physiologically. If we start in this manner, it will go smoothly. If we want to try to explain what the patient is doing on NAVA while we are thinking in terms of conventional mechanical ventilation, we will experience problems. That is the concept that I think we need to communicate to the intensive care community, and we need to communicate that NAVA will help the patients while they are using their diaphragmatic muscles, to provide the frequency that they need, the tidal volume that they need and the pressure that they want. We must educate that even if you might feel that the tidal volumes and pressures are erratic, they are determined by the patient. As long as the patient is comfortable and doing well, we should be satisfied.

We also look at the Edi in standby ventilation mode, or even with a test lung, as soon as the Edi catheter is placed. We can learn more about the behavior of the diaphragm as soon as we capture the Edi signal. We need to go more beat by beat to see what is happening to understand the physiological aspects of the neurally driven ventilation.

How does a team approach help you with successful implementation of NAVA? Does the team do a follow-up or review of the progress of each NAVA patient case?

Professor Idrissi: I believe we should follow the Edi signal before and after the NAVA ventilation and when the patient is weaned. I think it could be a good approach for new ICUs to learn about the Edi signals in other conventional modes of ventilation. One thing we need to work on is to gain an understanding of the signals and the underlying physiology when the signal is given. Particularly in small children when they are feeding, and if their stomach is overdistended, we need to see how this affects the diaphragm.

Dirk Danschutter: I would like to monitor babies with respiratory problems using the Edi monitor, in order to categorize these patients and track the respiratory distress season in September and October. When they come in, they are not ventilated but first receive oxygen or nasal CPAP. I would like to observe their Edi patterns and behaviors at this early stage. In children with this kind of distress we see diaphragm and Edi signal behavior, and if they get worse, we can track their diaphragm and Edi signals by monitoring before they are even ventilated. If this could be extended to 50 or 100 patients, it could give us perhaps Edi patterns or waveforms that could help us learn to illustrate the disease process.

Professor Idrissi: We would like to increase our experience with Edi monitoring to include the period before intubation and after weaning the patients. We see how the breathing is doing, and look at the artificial lungs to see how the breathing is progressing. In bronchiolitis season, we can start to monitor the Edi signal, give the patients some oxygen, and see how the patient is doing with an artificial lung. Maybe we can earlier see when the patient is in need of ventilation, before his situation worsens and becomes more critical. Monitoring these patients before ventilation and

after weaning will illustrate when to pick up the patient on ventilation and when to get him off more quickly. That is our challenge, to observe this progression and pattern in this patient category. If we have a monitoring system that gives us this information that sees earlier that the diaphragm and values are weakening, we can get them on the ventilator faster, and compensated earlier, and this helps us as a precursor to events. Early Edi monitoring can be a precaution in this way.

What in your opinion are the specific elements or factors needed in order to implement NAVA on a routine basis?

When we start NAVA, we follow it, even on the night shifts. We do not only use NAVA during daytime or office hours. The entire staff and all team members have been educated and trained, and once we initiate NAVA, we continue until it is no longer needed, and the patient is weaned. The confidence of all the staff is necessary, and everyone needs to be involved.

Do you think that this ICU will be expanding the use of NAVA in future?

Our experience will definitely grow as we go forward. I think the more an ICU can learn about NAVA, the more routinely NAVA will be used. We have some limitations, as we have several types of ventilators in the PICU. And as we have discussed earlier, something that we are working on, is that we need a better categorization of patients, and when NAVA should be implemented, this should not only be in the weaning stage but at earlier stages in the process. That is our next challenge, implementation earlier and in more types of patient categories.

Which types of patient categories are you most interested in gaining experience with, and why?

Bronchiolitis to begin with, this autumn will give us an opportunity to learn more about the physiological aspects of the patients and disease process. That is the category we will focus on in the near future and within the next year.

As this is a university hospital, do you see future educational training programs for NAVA for the medical students, the same as those that currently exist in conventional mechanical ventilation today?

Professor Idrissi: NAVA will absolutely be on the educational program, I am sure of that. We are teaching about different kinds of procedures, and that is the reason for the presentations on our intranet, as we have different fellows coming from Belgium and from abroad. All of those who are working with us need the same information. We give seminars on a yearly basis, and repeat these for the fellows as well as the nurses on the intranet.

Dirk Danschutter: For clinical nurse specialists, we are sure that they will want this type of continuing education, and practical aspects of the treatment, in a certain type of population.

Professor Idrissi: It helps us in our work that the physicians and the nurses are learning about our treatment culture and have the same understanding as we are learning new procedures, as we go forward.

Biography

Professor Saïd Hachimi-Idrissi received his Bachelor in Natural Sciences degree in Morocco in 1979. He obtained his Medical Doctor degree with Great Distinction at the Université Catholique de Louvain in Brussels in 1987, and his Ph.D. degree with dissertation entitled "Experimental and clinical studies on the neurological outcome after cardiopulmonary arrest" at the Free University of Brussels, Belgium in 2002. In addition to special competence in disaster medicine (1994), he obtained board certification in pediatrics (1994), emergency medicine (1995), neonatal care medicine (1997) and intensive care medicine (2005).

Prior to becoming Professor in Pediatric and Critical Care Medicine in 2005, Professor Idrissi obtained Fellowship at Safar Centre for Resuscitation Research, at the University of Pittsburgh, Pennsylvania, USA, and has also been active as European Instructor of Advanced Cardiac Life Support and Pediatric Life Support. He also lectured and worked as Assistant Professor at the Free University in Brussels Faculty of Medicine, as well as Director of medicolegal aspects at that institution. He is also Vice President of the Educative Program in the Master for nurses and midwives since 2006.

Professor Idrissi has published clinical studies extensively in peer-reviewed international publications, as well as acted as reviewer to the European Journal of Emergency Medicine since 1999. Professor Idrissi is well established on the international lecture circuit as moderator and speaker in numerous international critical and intensive care meetings over the past two decades.

Dirk Danschutter received his MSc degree from the Vrije Universiteit Brussels, VUB, Faculty of Nursing and Midwifery. He is Clinical Nurse Specialist, CCNS, with combination courses in critical care and pediatrics.

Dirk Danschutter has published research articles in a number of peer-reviewed journals, including a review article entitled "Tsunami: response to a disaster" in Crit Care Nus Clin North Am 2005; 17(4): 481-494.

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Thomas Similowski, MD, PhD, is head of the Department of Respiratory Medicine and Intensive Care, as well as Head of the Respiratory Pathophysiology Laboratory.

NAVA
– translating research into clinical practice

The world-acclaimed Pitié-Salpêtrière Hospital in Paris founded by King Louis XIV in 1656 was the world's largest hospital during the French Revolution, with a capacity of 10,000 patients. Today it remains one of the largest hospitals in Europe and is part of the Assistance publique – Hôpitaux de Paris. It is a world famous teaching hospital, with departments including most major medical specialities.

The ICU of the Department of Respiratory Medicine and Intensive Care of the Pitié-Salpêtrière Hospital has team members that have had a particular focus on cerebral cortex activation, control of the diaphragm, and variability and chaos in connection with mechanical ventilation, working actively at bedside as well as in research.

Critical Care News spoke with Thomas Similowski, MD, PhD, head of the Department of Respiratory Medicine and Intensive Care and head of the Respiratory Pathophysiology Laboratory and ICU physician Dr Alexandre Demoule to hear about their research and impressions of Neurally Adjusted Ventilatory Assist - NAVA.

Thomas Similowski, MD, PhD has been conducting research in the variability and chaos in mechanical ventilation, and is interested in NAVA in this respect.

Professor Similowski, can you tell us about the background to the research interest in variability and chaos in ventilation?

Professor Similowski: It all started with a series of papers published in the American Journal of Respiratory and Critical Care Medicine, in the late 1990s by the group led by Martin Tobin, who showed that, in normal individuals, a variety of stimuli such as imposing resistance to inspiration, hypercapnia, were associated with an increase of the breath by breath variability of breathing.

People tend to think that each and every tidal volume is the same as the one you had before. But they are not the same, there is some degree of autocorrelation, but if you look at tidal volumes sufficiently over time, it will be different and uncorrelated. This variability is considered as a witness of the degree of freedom of the respiratory system. If breathing is variable, it means that the interaction between the neuromuscular system on one hand and the mechanical impedance of the respiratory system on the other hand is sufficiently free to make a differentiation between the responses to define a margin of the adaptability. The exact meaning of the variability is not yet completely understood. Interestingly, each and every time you loaded the system, the variability decreased, and breathing tended to become more and more monotonous, and all the more so that the load imposed on the respiratory system was greater.

So it was interesting and our reflection then was if loading decreases variability in healthy individuals, this also should be the expression in acute respiratory failure. We went into weaning from mechanical ventilation and we studied the patients that passed a weaning trial and those who failed. In those who failed, we surmise that they failed because there was an imbalance between the capacity to overcome the load at that time, so we expected variability to be less in patients who were failing weaning trials, than in patients passing it. We did a multicenter study published in CCM 2006, and we showed that patients in weaning failure exhibited less variability than those who succeeded in weaning, but also that you could use variability in these cases to predict success or

King Louis XIV appointed architect Libéral Bruant to build the hospital on the site of a former gunpowder factory. Salpêtre, the French name for a constituent in gunpowder, provided part of the name for the new hospital in 1656.

failure in weaning. I think it was a big start for the team in this direction.

How did the research in variability lead to the research in chaos?

Professor Similowski: Breath-by-breath variability and respiratory chaos are not the same thing, even though we are more and more convinced that the second is a necessary condition of the first. When you look at variability you can explain the change in the breath-by-breath pattern through different mechanisms, short term memory, oscillations, that can explain about 20% of it. The rest is not accounted for. Some assigned it to "white noise", which did not really deal with the problem. So we looked at non-linear variability to see if this could explain the difference. It is how we became interested in non-linear variability of respiration, and we tried to write the initial paper, which was useful for us at a given point in time. We came to establish collaboration with Professor Poon at MIT, who is very advanced in the theory of chaos and autocalculation. You look at the flow signal of the ventilator, and say that is not sinusoidal, so that each breath is different from the other. This is variability. Then we look at the trajectory of flow, not looking at one breath after the other, and so you can define chaos in the trajectory. The first question is where does it come from? The second question is can this change in disease? The sources of chaos are multiple, they can be from the respiratory centers of the brain, they can be from the vagus nerve, etc. Also, you could send a sinusoid wave into the lung and because the lungs are highly non-linear in mechanical terms, the sinusoid wave could be transformed by the mechanics of the respiratory system. To answer this question, we took mechanically ventilated patients in the ICU, that were ventilated with SERVO standard ventilator 900C, and we observed that when the patients were under controlled mechanical ventilation, namely when all the command of breathing was coming from the ventilator, there was no chaos. And indeed there was no reason for chaos to be present in the ventilatory command that was defined by the electronic clock of the ventilator.

We thus ruled out the contribution of respiratory mechanics to chaos, which brings us back to the notion that chaos is an expression of neural control, and we have more and more arguments to state that chaos is an expression of neural control. In the patients I mentioned before, we studied them after switching them from controlled mechanical ventilation, with the ventilator clock doing all of the job, to inspiratory Pressure Support. The idea was if our theory was correct that we would see chaos in these cases, which indeed was the case. This was one additional element of proof that chaos is a product of the neural respiratory system. Interestingly, in the patients who were fighting the ventilation and not comfortable on inspiratory Pressure

Dr Alexandre Demoule is interested in studying the potential of NAVA to contribute to patient comfort or shorter ventilator time.

Support, there was more variability and more chaos than those who were comfortable on Pressure Support. So the idea is, very schematically, that ventilatory chaos is the sign that the neural control of breathing is active and can also indicate degree of stimulation.

What do you think are the next directions in this research, and in relation to NAVA?

Professor Similowski: The next step is how we can use this information in the clinical field. If we look at cardiology, for instance, the beat-by-beat variability of the cardiac rhythm or cardiac chaos is decreased during congestive heart failure, for instance. There are other examples, where for instance you can predict seizure from changes in the EEG chaos. So we have a full program devoted to investigate if changes in chaos are predictive or associated with the diseased state, such as ARF of COPD in the weaning state as well as other ventilator assistance modes. NAVA is currently the subject of an ongoing study which was conceived by a hypothesis that if you go from 0 level of chaos in controlled mechanical ventilation to some chaos during inspiratory Pressure Support, you have liberated the system between controlled and inspired Pressure Support. So if the claims about NAVA are correct, i.e. NAVA can bring patients closer to a physiological state and provide better assistance since it is more natural, then the hypothesis is that chaos and variability should increase when you switch from inspired Pressure Support to NAVA.

This is what we are currently investigating; the ventilatory flow of mechanically ventilated patients, and if we can determine that patients having difficulty with ventilation on Pressure Support should benefit from NAVA. We will place the Edi catheter and continue to report flow and chaos to see if it is different, more or less, and to see if it is proportional to the degree of assistance provided. If this is the case, it would be the first human clinical study demonstrating that actually NAVA is different from Pressure Support in terms of something related to breathing control. This is one of the most interesting patient categories to investigate, since

Professor Thomas Similowski

they are having difficulty on Pressure Support. There is a lot of literature about asynchrony, but what counts is what the patients are feeling. Another question in this study is to measure comfort in disease on these cases, and to see if switching from Pressure Support to NAVA influences patient comfort. We hope to find a relation between variability and the degree of comfort.

It is important to state that chaos is not disorder in this case, but chaos and variability are signs of good health on a u-shaped curve, in this perspective. In terms of variability in respiration, people who are too variable are unstable, for example patients with asthma who have a lot of variability, which is not a good sign. The same is true in cardiology. But the most common mistake is to misunderstand chaos and variability. In the spontaneously breathing patients we believe that variability and chaos are signs of well-being.

Can you share any observations from this early stage of research?

Professor Similowski: It is very early in the process, but in patients without underlying respiratory disease, the first few experiences with NAVA have been very clear-cut. In switching to NAVA, you increase variability and chaos.

You have conducted substantial research in the areas of inspiratory resistance, and diaphragm response in regard to cerebral activation and stimulation. Based on this physiological background, what are your ideas related to asynchrony and respiratory load affecting the EEG?

Professor Similowski: We are not yet there, although we have started a research program that up to now has shown that in normal individuals when you load breathing, there is a cortical activity that appears and can be described with EEG. This has been shown in normal subjects receiving inspiratory loading, on non-invasive mechanical ventilation when you change the ventilator settings in such a way that makes him/her uncomfortable. When he/she is comfortable, there is no EEG signal showing cortical activity. The next step is to see if patients receiving mechanical ventilation have this type of reaction, and then to see if NAVA makes a difference in cortical response in terms of fighting the ventilator. This program is not yet started; we are buying a top-notch EEG system in the near future in order to study this area later this year. We will need a few patients to prove this concept.

Dr Demoule, can you share with us something about your background and research interest in this area?

Dr Demoule: I am a critical care respiratory physician within the medical ICU. I have also done some research on the control of the diaphragm. It is one of the main research topics for our team; the diaphragm as a muscle and the control of breathing. I have been working in this area for 10 years, and it has a special focus from a large part of our department. Primarily we were interested in NAVA because of our research background; it was a link in the clinical translation from the research to the patient.

Which are the general patient categories that you are treating in this ICU?

Dr Demoule: All kinds of medical ICU patients. Most of them present

with acute respiratory failure. Among them, one of our main categories is acute or chronic respiratory failures, most of which are not intubated but treated non-invasively. We have acute cardiogenic pulmonary edema patients, most of whom also receive non-invasive mechanical ventilation, and other categories include those who are admitted for a de novo acute respiratory failure, such as pneumonia, ALI –Acute Lung Injury and ARDS – Acute Respiratory Distress Syndrome.

We treat about 600 patients a year in the ICU and 300 patients in the stepdown unit.

Dr Alexandre Demoule

What conventional mechanical modes or ventilation therapies do you use most frequently?

Dr Demoule: We use very conventional modes, Assist Control ventilation in coma patients and in those with sedation. We try to wake up patients as early as possible and switch to Pressure Support as soon as possible. We do non-invasive ventilation in the indications that are supported by current guidelines. Indeed, most of acute or chronic respiratory failure and cardiogenic pulmonary edema patients receive non-invasive ventilation as a first line treatment. We also do non-invasive ventilation in the post-extubation setting for patients at risk for post-extubation respiratory failure.

What is your experience with NAVA at this point?

Dr Demoule: We have used NAVA in at least 15 patients. When we started, we made sure that all the nurses in the team were trained in NAVA, and since NAVA is a new mode of ventilation, we think that the nurses need to be trained properly. We started very slowly in order to learn together, in November, and have been increasing our experience since March. We want to make our own idea of how NAVA really works, if it is possible to ventilate the patient several days on NAVA. We have only run NAVA for about 18 hours, initially. We wanted to gain our own experience of how NAVA works; how to place the Edi catheter, how it works in daily practice in terms of time consumption, and if it is feasible. We are now trying to do a lot to gain stepwise experience. Now we really want to know if it is possible to treat patients on a routine basis with NAVA.

Which types of sedation and dosage levels have been used in connection with patients treated with NAVA, and what have you observed in these situations?

Dr Demoule: Most of our patients receive Midazolam, and Sufentanyl. Since the goal of NAVA is to increase patient-ventilator synchrony it is not very interesting to use NAVA in too heavily sedated patients. We use NAVA in patients with a Ramsay score equal to or lower than 4. It is too early to draft conclusions regarding NAVA and sedation.

Have you observed variations of Edi signal behavior among the different patient categories?

Dr Demoule: Up to now we have not gone into specific categories, but obviously we are interested in COPD patients because of the wasted efforts, and we think that NAVA could be useful in this respect in these types of patients. We don't intubate many of these patients, so we don't have a big opportunity yet. Intellectually we are interested in this category, but on a

daily basis these patients are not usually intubated. We have a lot of other patients, ALI patients or pneumonia patients that have been ventilated with Pressure Support, in which we have used NAVA.

What are your general impressions so far?

Dr Demoule: It is early yet. But we think it is feasible to place the Edi catheter and run NAVA. Sometimes it takes time, so I think that there is a learning curve and practice is needed to improve the process. We don't know yet if it is feasible to do NAVA continuously for a longer term. We need more time and experience. It is a completely different mode of ventilation, for the nurses and for us physicians.

How do you usually set the NAVA level?

Dr Demoule: Nobody really knows how to set the NAVA level yet – we are trying to set our own guidelines, so we are using NAVA level 1 usually to start out with. This is a new parameter for us. We do a recruitment curve, we increase the NAVA level step by step and we find what is the best in terms of enough tidal volume and pressure. With a Ramsay score of 4 it is difficult to determine comfort level of the patient, with a Ramsay 3 or 2 it is a little easier, and you are able to talk to the patients and so on. We aim for certain tidal volume targets without increasing too much pressure.

Are you sure that the tidal volume you target is the level of tidal volume that the patient wants?

Dr Demoule: No – to be sure, obviously. The subject of tidal volume is a never-ending story. We know that ARDS patients must be ventilated using protective ventilation. For other patients, specifically for those who breathe spontaneously, we target 6 to 8 ml/Kg body weight. There are a few cases where we have reduced the NAVA level because the patient did not need so much assist.

Have you specific patient cases of interest, where the Edi signal revealed something you did not expect to see, or where NAVA provided results that you did not expect?

Dr Demoule: We have seen, in patients that have a very pathologic diaphragm, it is difficult for NAVA to get a good signal. In one case in particular, with severe diaphragm atrophy, it was hard to get good signals. One patient had been on mechanical ventilation for two months, and another had neurological disease. We had weaker Edi's in these patients.

Do you see any other research areas of interest for NAVA, additional to the ones we have already discussed?

Professor Similowski: I think that for example, NAVA is interesting to determine what is the difference between just triggering the ventilator from the Edi signal, versus the current concept from the EMG. Non-invasive ventilation with all of the problems with leakage, this is an interesting area as well.

My impression is that NAVA is more easy to use than I thought, from a clinical point of view. Everyone knows how to place the nasogastric tubes, and position the Edi catheter by the ECG leads. The people here are very familiar with respiratory mechanics so they are trained to know what to find. In our unit it appears to be easy, due to our background, experience and physiological focus.

Dr Demoule: I think that the next step is to implement a series of clinical studies to determine if prolonged NAVA is feasible. In other terms, whether NAVA works continously over time or not. It is also time to start controlled trials in order to determine the clinical benefit of NAVA. Interesting outcomes are duration of mechanical ventilation, patient-ventilator asynchrony and patient's comfort.

Right now we know that NAVA works on a short term basis, but as we know, there are not so many ventilatory modes that really are used by many physicians in the world in daily practice. There are a lot of ventilatory modes that were invented, and some were not so useful. Assist control ventilation and Pressure Support are really used but these are more than 20 years old, and Pressure Support took time to be accepted. NAVA now needs clinical trials.

The Pitié-Salpêtrière Hospital, surrounded by lovely parks, is located in the center of Paris.

Biography

Thomas Similowski, MD, PhD
Thomas Similowski, MD, PhD conducted his initial medical studies during the years of 1979-1984 at the University of Paris, followed by specialty residency at Assistance Publique-Hôpitaux de Paris (Paris Public Hospital System) during 1984-1990. During the years of 1988-1989, Dr Similowski was Research Fellow at Meakins-Christie Laboratories, McGill University, Montréal, Quebec, Canada as recipient of the Lavoisier Grant from the French Ministry of Research. He was Junior Registrar at the Department of Respiratory Medicine, Pitié-Salpêtrière Hospital in Paris during the years of 1990-1994, and Senior Registrar at the same institution from 1995-1998.

Thomas Similowski attained the position of Full Professor, Respiratory Medicine in 1998 at Pitié-Salpêtrière Hospital. He is currently head of the Department of Respiratory Medicine and Intensive Care, as well as Head of the Respiratory Pathophysiology Laboratory at Pitié-Salpêtrière Hospital in Paris.

In 2004, Thomas Similowski was Laureate of the 3rd edition of the French national "Victoires de la Médicine" for work done on phrenic nerve stimulation in tetraplegic patients. He was Associate Editor of the "Revue des Maladies Respiratoires", the official organ of the French learned society for respiratory medicine from 1992-2000, and Chief Editor of the same publication during 2001-2004. Thomas Similowski has been member of the Editorial Board of Respiratory Physiology and Neurobiology since 2005, and member of the Editorial Board of the Journal of Applied Physiology since 2006.

Thomas Similowski has conducted and published scientific research extensively. He is author or co-author of over 154 articles in peer-reviewed biomedical journals and author or co-author of more than 120 book chapters and CME articles in medical journals. He is also editor or co-editor of 14 books, including 2 volumes of the "Lung Biology in Health Diseases".

Alexandre Demoule, MD, received a Master's Degree in Biological and Medical Sciences in 1994, and Doctorate Degree in Biology and Physiology of Circulation and Respiration in 1998. He obtained his Medical Degree in 2001, followed by specialized degrees in Pneumology (2001) and Intensive Care (2005). In 2006, Alexandre Demoule obtained the degree of PhD with Speciality in Physiology and Pathophysiology at the University of Paris.

Alexandre Demoule served a Speciality Internship during the years of 1994-2000 at the Interregion Paris Agglomeration, followed by the Silver Medal of Paris Internship from 2000 to 2001. He served as Resident in the Department of Medical ICU at Henri-Mondor Hospital University Centre from 2001 to 2003, and was Research Fellow at Meakins-Christie Laboratories, McGill University, Montréal, Quebec, Canada from 2003-2004. Since 2004, Alexandre Demoule has served as Assistant to the Head of the Department of Pneumology's ICU unit at Pitié-Salpêtrière University Hospital group in Paris.

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Respiratory therapist Ji Gang and Dr Zhu Limin with infant cardiac surgery patient, post-op on ventilation with NAVA.

NAVA in the post-operative treatment of congenital heart disease infants

The Shanghai Children's Medical Center, affiliated to Shanghai Jiao Tong University School of Medicine, was jointly constructed and established ten years ago by the U.S. based Project Hope, the Shanghai Municipal People's Government and the Xin Hua Hospital. Ever since the inauguration ceremony with U.S. First Lady Hillary Clinton in June, 1998, the Shanghai Children's Medical Center has made rapid progress in the areas of pediatric cardiology and surgery, improving the lives of Chinese children with congenital heart disease, as well as establishing comprehensive cooperation and training collaboration with over ten well-known medical institutions around the world.

The Department of Cardiovascular Thoracic Surgery of Shanghai Children's Medical Center is the key program of the Shanghai Bureau of Higher Learning, and the first clinical medical center for pediatric cardiology and cardio-thoracic surgery. In addition to becoming a clinical educational and research center, it is the national top-ranking diagnostic and treatment center for congenital heart disease.

The latest advancement within the Department of Cardiovascular Thoracic Surgery is the implementation of NAVA – Neurally Adjusted Ventilatory Assist in the post-operative treatment of infants undergoing congenital heart surgery. Critical Care News met with the staff of the CICU, who shared their recent and expanding experience of Edi monitoring and NAVA as a treatment modality.

Intensive care physician Dr Zhu Limin, ICU Chief Dr Shi Zhenying and respiratory therapist Ji Gang.

Can you give us a description of the operations of the Department of Cardiovascular Thoracic Surgery and the CICU?

ICU Chief Dr Shi Zhenying: Our department, cardiovascular thoracic surgery and the CICU here at Shanghai Children's Medical Center have been in existence for 10 years, ever since the hospital was constructed.

We have 9 physicians on staff in the CICU. I have been chief of this unit for the past 10 years, ever since the beginning. Prior to that I was surgeon at the Xin Hua hospital, and thereafter I was an intensive care physician for 10 years, before my current position as chief of this unit.

How many children are treated in the department on an annual basis?

Dr Shi Zhenying: At the present time, we conduct surgeries for nearly 3,000 infant cases on an annual basis. We receive patients from Shanghai, as well as other cities and the countryside. They are born with congenital heart defects and sent here for surgery.

Diagnosis and treatment of congenital heart disease is one of the primary specialization areas at this center. How many patients in this category do you treat on an annual basis, and what other types of patients do you treat in addition to these?

Dr Shi Zhenying: We treat infant patients with acute and complex congenital heart disease, pulmonary artery atresia and infants with single ventricles. About 90% of our caseload consists of babies born with congenital heart disease. The other 10% of patient categories are here due to many different factors, such as lung disease and various types of congenital tumors. We have achieved an overall success rate of 97%.

Which ventilation therapies do you most frequently use in these patient categories?

Dr Shi Zhenying: Primarily we use synchronized intermittent mandatory ventilation - SIMV. We also use PRVC – Pressure Regulated Volume Control as well as Pressure Support ventilation. The mode of mechanical ventilation we choose is always dependent upon the patient condition and sedation levels.

Can you describe the primary factors and process leading to the decision to implement NAVA in this CICU?

Dr Zhu Limin: The first time we heard about NAVA was two years ago, when our chief Dr Shi Zhenying attended a symposium at the ESICM meeting in Barcelona, and she heard the

Dr Zhu Limin and colleagues with patient on Edi monitoring, post-extubation after NAVA ventilation.

lecture by Dr Christer Sinderby. She informed us of this new technology, and I received much information about NAVA, and I became very interested.

When did you have your first patient experience with NAVA, and how many infants have been treated with NAVA so far?

Dr Zhu Limin: We had our first patient experience with NAVA only two months ago. We have placed the Edi catheter in about 16 patients, and treated about twelve patients with NAVA. The other four cases were babies with diaphragmatic paralysis, and since the babies were not spontaneously breathing, we could not use NAVA in those patients. However, in using the Edi catheter, we were able to monitor the Edi and detect the paralysis in these four cases. Some patients develop a bilateral diaphragmatic paralysis after surgery, so the Edi monitoring will confirm this by indicating no Edi signal.

How routinely is NAVA used in the ICU?

Dr Zhu Limin: We have been gaining a lot of experience since we just started using NAVA only two months ago, so now we are selecting more difficult cases to gain even more experience with Edi monitoring and with NAVA. For the patients we have treated with NAVA, they have been on NAVA for a range of times, between a few hours up to three days, depending on their condition.

Is monitoring of the Edi signal used in conventional ventilatory modes, or in stand-by post-op after extubation?

Dr Zhu Limin: For patients that have had diaphragmatic paralysis, we want to leave the Edi catheter in for 2-3 days to monitor the status of the diaphragm. Our surgeons need verification; so now we can give all this information to them, ultrasounds, Edi signals and X-rays, so that they see the actual condition of the diaphragm. It is very interesting and very useful for the surgeons. For our NAVA patients at post-extubation, we leave the Edi catheter in for another 24 hours just to monitor the Edi, if we suspect the patient may re-develop something, or just to confirm that their spontaneous breathing is doing well on their own. We have been doing this as a routine for our NAVA patients. We have also monitored the Edi signals in other modes, such as Pressure Support,

ICU Chief Dr Shi Zhenying surrounded by her staff members Bian Jun, Ji Gang, Zhu Limin and Liu Liping.

to monitor diaphragmatic status.

What in your opinion is the advantage or benefit of Edi monitoring as a bedside parameter?

Dr Zhu Limin: I think it is very useful. For example, just in the past two days, right after surgery we had a patient with a low Edi signal and very labored breathing, but after 12 hours the Edi signal became much stronger. We switched the patient to NAVA and yesterday we successfully extubated him, and now we are just monitoring the Edi signal. I think the Edi signal is very helpful and useful; you can get answers to all kinds of questions during the treatment process. It is a new bedside parameter for us. I think that maybe the Edi signal can tell us about sedation levels and the wash-out process and behavior patterns of the patient coming out of sedation that we were not able to see before.

How do you perceive NAVA from a therapeutic perspective?

Dr Zhu Limin: From our CICU department, I think we have two patient perspectives. On the one hand, for the simple cases after cardiac surgery, you want to extubate them as safely and as quickly as possible. If you place the Edi catheter and use NAVA, and find the Edi signal returning after surgery, the patient can be extubated as early as possible. On the other hand, in complex cases, the patient needs mechanical ventilation for some longer lengths of time. If we use NAVA, the patient and ventilator are in synchrony, which means that the baby is more comfortable, and the dosage of sedation can be reduced. The Edi monitoring gives the opportunity to extubate earlier as well as monitor the sedation process.

Do you think esophageal ECG is valuable as a diagnostic tool in this patient category?

Dr Zhu Limin: Esophageal ECG is very important for us, as our open heart surgery patients sometimes have post-operative arrhythmia. From the normal ECG, we cannot always see a clear diagnosis, such as SVT, or sometimes atrial tachycardia. If we have an esophageal ECG, we can see the correct diagnosis of the arrhythmia, which is very useful for our treatment.

Respiratory therapist Liu Liping and Dr Zhu Limin.

Have you had any infant patient cases with NAVA of particular interest you would like to share?

Dr Zhu Limin: We had a baby which came to the hospital at two months of age, who was suffering from transposition of the great arteries. An emergency operation was necessary, and it was very difficult to extubate him. We had three failed extubation attempts, with breathing difficulties and bronchospasm. We performed a bronchoscopy contrast CT, which revealed another problem, a vascular ring that compromised the trachea. Another surgery was performed to resect the vascular ring. The patient had been in the CICU for about one month. After the second surgery, we placed the Edi catheter and treated the child with NAVA. He was spontaneously breathing with NAVA for about three days, followed by a successful extubation. One week later, we were able to finally discharge him. *(Editors note: details of this patient case report may be found at www.criticalcarenews.com).*

Are there specific staff members using NAVA, or has the general ICU staff received training?

Dr Zhu Limin: All of the CICU staff has received training, doctors and nurses. We have also trained our RT group for special cases, so everyone has been educated. Our respiratory therapists place the Edi catheter and verify the positioning.

How do the respiratory therapists experience the Edi catheter placement and positioning process?

Ji Gang, RT: It is not very difficult to place and position the Edi catheter, and we just monitor placement by means of the ECG signals. We use the Edi catheter as a normal feeding tube as well.

As a team, we have a follow-up after each NAVA treatment for every case, so that we can all continue to learn about NAVA together.

What role do you think NAVA will have in the future in this patient population of congenital heart defects and disease?

Dr Zhu Limin: I think that NAVA will be used increasingly in cardiac surgery, especially for pediatric patients, because of the opportunity of earlier extubation for simple cases post-op, and for complex cases, the opportunity to monitor Edi and diaphragmatic status, in order to monitor and decrease dosage of sedation. Also, I think that the NAVA technique is easy to learn for any ICU staff member.

Do you think that your institution will be researching and expanding the use of NAVA in future?

Dr Zhu Limin: I think that the research is very important, and we are planning to do some research in three areas. First, we would like to compare NAVA with traditional Pressure Support ventilation in terms of patient-ventilator synchrony as well as if we determine reduction of sedation dosages. Secondly, we are interested in research with NAVA to confirm the safety of hemodynamics in cardiac surgery patients. One other area of research we are interested in is to measure the Edi signal after extubation and chart and track to establish the normal range for children. ■

Biography

Dr Shi Zhenying, MD, received her medical degree in 1975. She worked in Xinhua Hospital from 1975 to 1999, and was employed as physician of the cardiac intensive care unit there from 1989.

Dr Shi Zhenying has been the chief of the cardiac intensive care unit of Shanghai Children's Medical Center, China since 2000. She was versed in the clinical and research work in perioperative treatment for congenital heart disease in children, especially in the prevention of low cardiac output syndrome and the treatment of multiple organ dysfunction syndrome.

Dr Zhu Limin, MD, obtained her medical degree in 1999. Thereafter she was employed as a physician of the cardiac intensive care unit at Shanghai Children's Medical Center, China. She received the fellowship of respiratory therapy and pediatric intensive care in Schneider Children's Medical Center of Israel in 2006.

She has been the manager of the team for respiratory management in the Cardiac Intensive Care Unit since 2006. She specializes in treatment of pulmonary hypertension and post-operative lung protective mechanical ventilation. From 2008, she has conducted clinical research of NAVA in neonates and pediatrics following cardiac surgery.

The Shanghai Children's Medical Center was established 10 years ago, and has become an internationally known center for treatment and research.

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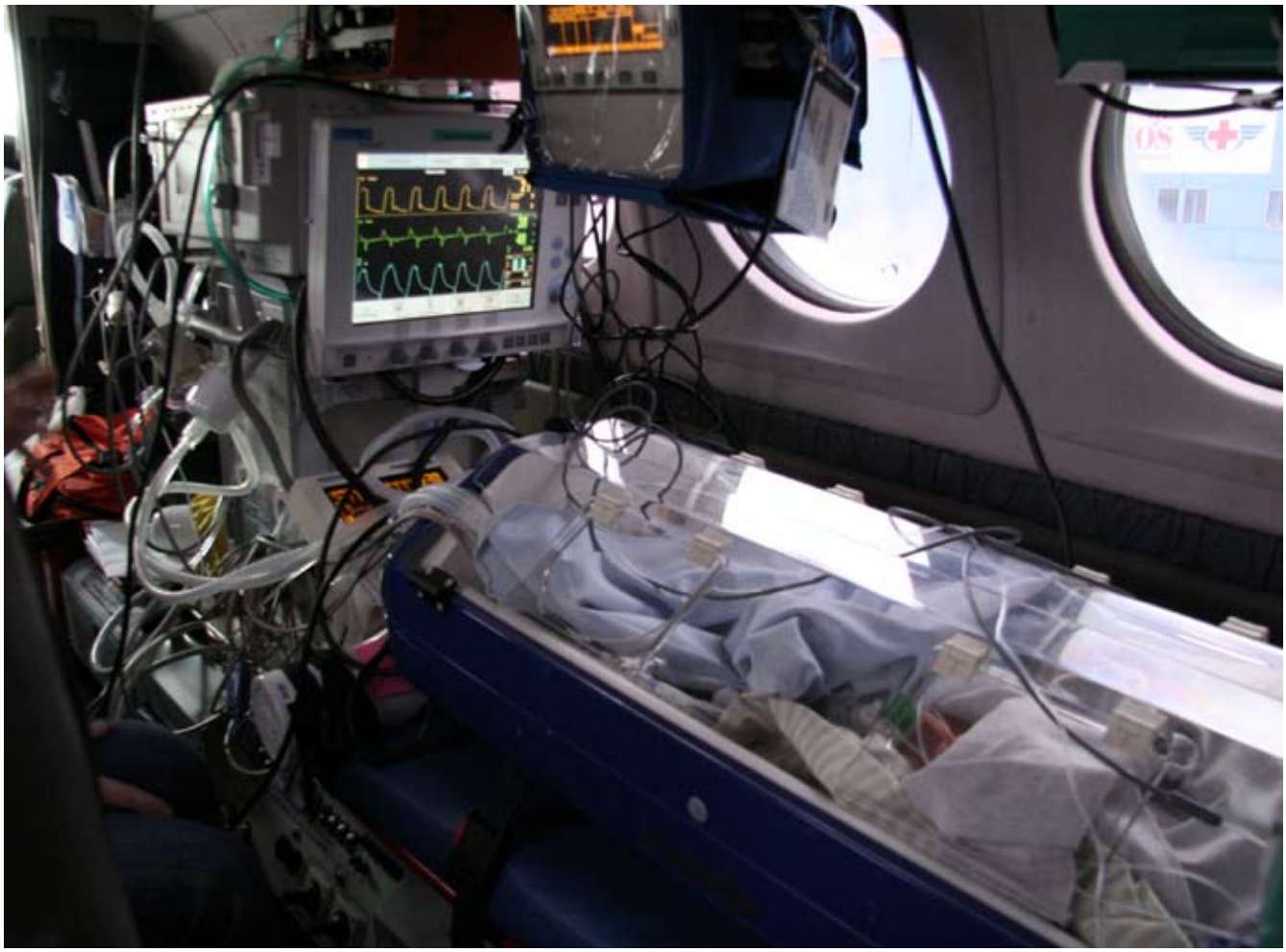


Infant patient in aircraft, ready for air transport from Sweden to northern Europe, with BabyPod and SERVO-i transport solutions.

Ventilating infants in critical care air transports

Over the past two years, more than 40 critically ill infants have received intensive care quality ventilation in air transports within Sweden and destinations in northern Europe. These transport opportunities have evolved from a close collaboration between the Swedish Air Ambulance company (Svensk Flygambulans AB) and the Astrid Lindgren Children's Hospital at the internationally renowned Karolinska Hospital in Stockholm, as well as new technological solutions that provide support to ventilated infants in fixed wing aircraft.

Critical Care News met with team members of this collaborative effort from both groups; representatives from PETS (Pediatric Emergency Transport Service) at Astrid Lindgren Children's Hospital, as well as representatives from Swedish Air Ambulance, to hear about how this collaborative effort and transport solutions developed within the group.

Demonstration of the BabyPod mounting on the transport stretcher with SERVO-i ventilator anchored in place.

The Pediatric Emergency Transport Service (PETS) at Astrid Lindgren Children's Hospital and the Swedish Air Ambulance company each have a longstanding tradition of transporting critical care and emergency patients.

The PETS service – with origins in the early 90's

The Astrid Lindgren Children's Hospital within Karolinska Hospital in Stockholm has a long and well-established tradition of transporting children, primarily newborn infants, originating from a decision to centralize cardiac surgery in Sweden to the university hospitals in Lund and Gothenburg in the 1990's. Dr Tova Hannegård Hamrin, anesthesiologist at Karolinska's Astrid Lindgren Children's Hospital, outlines the development process after that point: "We came to believe that there were many critically ill children in general ICUs in hospitals around Sweden, who would perhaps get better care in a dedicated pediatric intensive care unit. That is how the idea for PETS was born, and it started as a project in 2005. We have observed that more and more hospitals have contacted us to transport and treat more and more children." Dr Hamrin has been involved in the PETS program from the very beginning, and is currently responsible for PETS operations, which is a part of the Department of Pediatric Anesthesia and Intensive Care group at Astrid Lindgren Children's Hospital.

"Last year we had 27 PETS transports in total, from January to April this year we are already up to 18 PETS transports, an increasing tendency. I think this increase is due to familiarity and confidence, once a hospital has heard about the program and sent one of their children to us and seen that it works, they want to use us again. PETS are not only air transports, but also land based ambulance and helicopter intensive care transports as well. Whatever the transport means, the program can be considered as a mobile ICU for infant and pediatric patients."

The PETS program has twelve physicians as well as twelve nurses, in order to provide staffing around the clock. Dr Hamrin explains: "In the very beginning, staffing was on voluntary basis among our colleagues. A patient transport request came to the doctor on call at the PICU, who then contacted us by mobile text messages that were sent to all of us, and those who had the opportunity to accompany the patient transport could respond. From the beginning of this year, we have chosen to have one physician on rotation for transports for one week at a time. We are also working on a proposal for a rotational schedule among our pediatric intensive care nurses and pediatric anesthesia nurses. It is extremely important that our PETS staff have a good knowledge of how we care for our patients, and that they have worked at least two years at our unit in the hospital."

Swedish Air Ambulance – over 30 years of operations

The Swedish Air Ambulance company started its operations in 1976 with the very first air ambulance in Sweden, and has continually developed ever since. Last year over 1100 patients in different categories were transported, in a fleet of three Beechcraft 200 aircraft based in Sweden. Managing Director Åsa Englund states "We fly primarily in Sweden and northern Europe on flights between 2-3 hours. After that, refueling is usually necessary, but is also dependent upon the load that the aircraft is carrying. Each flight has a captain, co-pilot, and aircraft nurse. We have a high requirement for our nurses, who must have flight medical training, emergency training, and maintain clinical competence in order to provide patient care, in case there are situations where no PETS team members are present.

Swedish Air Ambulance acting Managing Director Åsa Englund has been employed at the company since 2001, and has been actively involved in the technological developments.

Over 90 % of the transports are planned, and 10% are acute, according to Åsa Englund, and the company transports in any situation around the clock. Registered Flight Nurse Carina Ramstedt explains: "It could be a patient that has to be transferred to a specialty center for transplantation, or a patient returning home after specialized care. Sometimes we get patients that have become ill during a business trip or vacation trip. We can provide flight support like an ambulance, ICU or sometimes the patients are capable of sitting upright. We also act as an extended arm. We had a number of patients that arrived in Sweden after the tsunami 2004, who were transported back to their home hospitals."

Collaboration leads to new infant transport solutions

Karolinska Hospital and Swedish Air Ambulance have collaborated with patient transports for many years, in many different patient categories.

The PETS group has used different transport solutions for infants, with different experiences and drawbacks. Dr Hamrin explains about some of the limitations they have encountered and the discovery of the infant pod solution: "When you transport with an incubator, the infant is the component that weighs the least. Transport incubators are large and cumbersome, and not easy to work with. One of our colleagues heard about the infant pod solution in Great Britain, where it has been in use for some time. We purchased one infant pod (BabyPod manufactured by Advanced Healthcare Technology Ltd, U.K.) and started to use it for transports of our infants with congenital heart disease, and it worked very smoothly. In about the same time frame, SERVO-i ventilator became available for air transports. The transport incubators today have a rather basic ventilator solution that does not provide high quality ventilation treatment. "

The Swedish Air Ambulance became very interested in the infant pod solution that the PETS group had discovered, since it is a much simpler solution to travel with when a transport incubator is not really needed. Dr Hamrin states that the only time when a transport incubator can be needed is when the infant cannot maintain body warmth, which generally is only a problem with premature babies, in her opinion.

Annika Schön, anesthesiology nurse in the PETS group, describes the infant pod solution: "The infant pod is lightweight as it is composed of styrofoam, and has a five point strap system crossing over the child as a harness to keep the infant in place on the mattress. The mattress is a vacuum type, which can be adjusted if the child needs further support within the pod. The pod is affixed to the stretcher at the hospital, and the concept works as one unit from the hospital to the aircraft, during flight and upon arrival at the receiving hospital. "

Intensive care ventilation in-flight

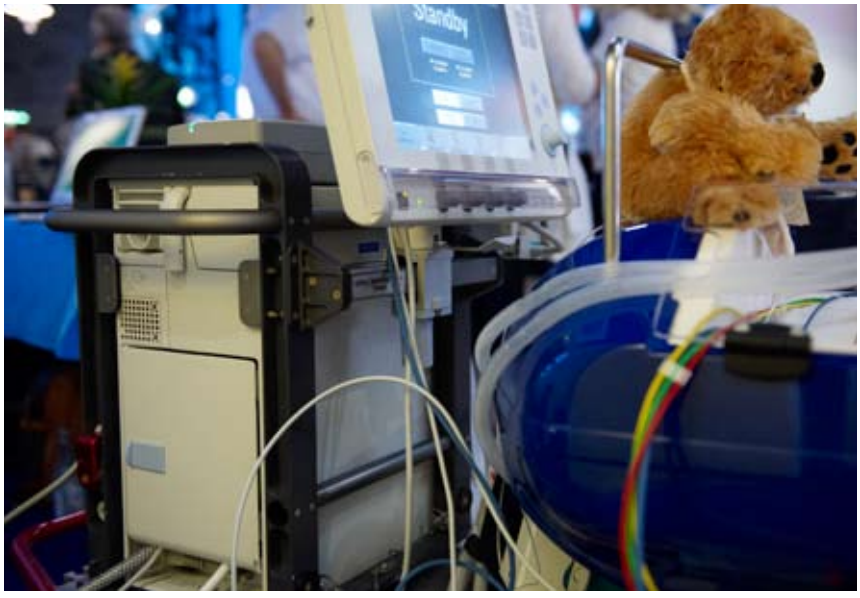
The pod solution became very popular for transporting infants, but ventilation was an issue that still needed to be addressed. Swedish Air Ambulance Flight Nurse Carina Ramstedt describes some of the practical problems of the past: "For infants, the greatest concern has always been the risk of extubation when entering or leaving the aircraft. We always worry about tubes or cords fastening somewhere, or movements that might disturb the patient and the equipment, such as one of the staff stumbling, etc."

For the PETS team, the quality of ventilation treatment for infants has been a primary concern. Dr Hamrin explains: "When PETS began, more than 70% of our transported patients were referred because of respiratory insufficiency. In transporting these infants with sick lungs, it can affect the level of treatment quality to transport without a high quality ventilator. We were purchasing the SERVO-i in the hospital to replace our old SERVO 300 fleet in the PICU, and as the SERVO-i can be adapted for transports and was approved for flight, the idea was born to transport with a ventilator that provided ICU quality ventilation, and to use it on the infant during the entire course of therapy, including bedside. This helps us maintain the same ventilator quality without interruption."

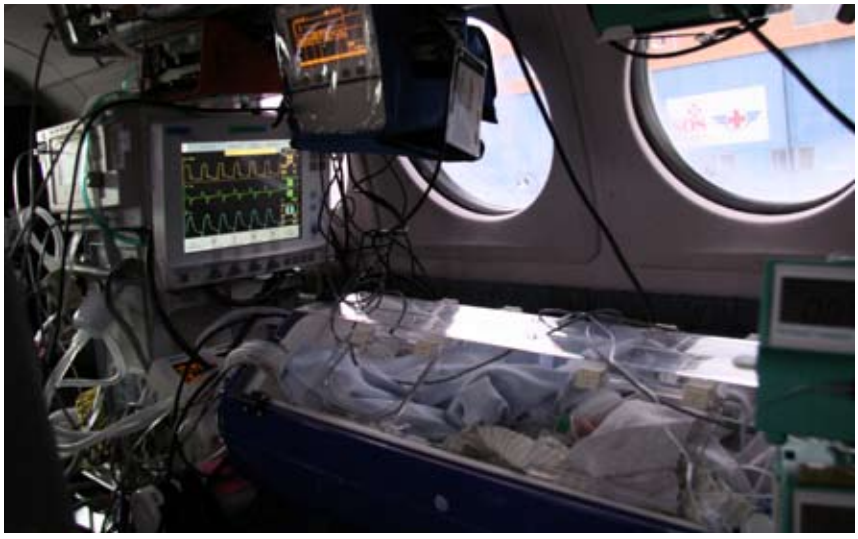
"The Swedish Air Ambulance company was attentive to us when we discussed the fact that the old model of baby transport ventilator was not sufficient for these infants with sick lungs. In the process we took a SERVO-i ventilator and received flight approval for it, and they followed the same process. They also heard about the transport cage to attach and stabilize the SERVO-i to the stretcher, and informed us, as they have always been very attentive to our requirements in regard to ventilation quality during the transport process. The collaboration continues to develop."

The Swedish Air Ambulance company initiated a process to be able to use the SERVO-i ventilator in flight. Åsa Englund clarifies: "We developed the solution to anchor the ventilator and cage to the stretcher on a bottom plate, which is stable from all directions. After that we conducted a series of tests to evaluate stability, electrical disturbance on other instrumentation, and tests to establish that the ventilator was not affected by changes in cabin air pressure or vibrations, and tests of the connecting cables as well." The Swedish Air Ambulance company appreciated the concern about the quality of ventilation in flight. Åsa Englund points out: "It is important that transport of these small ICU infant patients should just be considered as a continuation of the treatment and care they have received at bedside. They are treated in the pediatric ICU, and during the air transport process the treatment should continue smoothly at the same level as at bedside, the only difference is that we are moving the patient from Point A to Point B."

Carina Ramstedt is Flight Nurse at Swedish Air Ambulance.



The ventilator is securely mounted to the stretcher by means of a special transport cage, which maintains stability throughout the flight.



The single unit concept, with ventilator and infant pod attached to the same stretcher, has increased ease-of-use and minimized risks, according to staff members.

Single unit concept – infant pod and SERVO-i mounted to the same stretcher

After the different stages of the process, with the discovery of the infant pod solution by the PETS team, and the flight validation of the SERVO-i and transport cage solution by Swedish Air Ambulance, the one unit concept was first utilized during an infant transport flight from Sweden to Dublin, Ireland. Carina Ramstedt recalls the first experience: "The opportunity of mounting the ventilator on the same stretcher where the child is positioned in the pod makes the solution a single unit, which provided a new sense of security. In the past, it has always been a concern with separate lifts of the ventilator and the child, with concern for the tube and risk of extubation. The single unit concept of infant pod and SERVO-i worked very well, and made our work easier."

Annika Schön who has flown for many years with PETS at Karolinska Hospital in cooperation with Swedish Air Ambulance, agrees that the current single unit solution that so many have contributed to, with the infant pod and SERVO-i ventilator both fixed on the same stretcher has made the process much easier. "Since the children we treat have respiratory problems, we do not like the traditional infant incubator-based transport ventilators. These old traditional infant transport ventilators have a lower level of clinical performance, and sometimes we had to increase sedation for the patient in order to ventilate them on the older transport ventilators. Since we have SERVO-i in the PICU, it delivers ventilation with the clinical performance that is required by these infants with respiratory problems, at bedside in the PICU as well as in the air during transport. This is the most optimal situation for the patient if they receive their treatment on the same ventilator at bedside in the ICU prior to transport, in flight during transport and at bedside at the PICU at the receiving hospital. This also means that treatment parameters, such as settings and sedation levels, can remain the same. For us staff members, it is also optimal from the perspective that we are working with the same equipment in flight that we know and use at bedside in the unit."

She has also noted increasing trends in acceptance and utilization of the solution: "From November 2006 up to and including the year 2007, we had 27 air transports with the single unit infant pod/SERVO-i ventilator solution. Interestingly, so far this year in the first four months from January to May first, we have already had 18 transports. There is a growing tendency to request and utilize this solution. I think perhaps it is due to the fact that hospitals throughout the country are becoming familiar with this possibility, contacts have been established and they see that the transport solution has worked well. I think that we have passed an initial level of knowledge and acceptance, and the requests for infant transports with this solution will continue to grow."

Bedside quality ventilation therapy - wherever the infant may be

Dr Hamrin also addressed the benefits of using the same ventilator in the ICU and in the air. "We have many SERVO-i ventilators that are approved for flight, so it is a benefit if the child can continue ventilation on the same ventilator upon arrival without having to switch ventilators. It is what is best for the infant, and reinforces our ambition to provide the same level of quality in ventilation therapy in the air as well as bedside in the PICU."

Swedish Air Ambulance Beechcraft 200 aircraft.

Tova Hannegård Hamrin, MD, is Director Pediatric Anesthesia at Astrid Lindgren Children's Hospital, and has been responsible for the PETS program since 2005.

The infants that are critically ill are most often on Pressure Control ventilation, according to Dr Hamrin. "We can change setting parameters during transport, just like we might do bedside in the PICU. We do not usually require muscle relaxants for the infants during transport. Sedation may be used during transport, since the child may be critically ill prior to transport and is sedated at the hospital of origin. We try to use the same trigger settings in transport that have been used at bedside. We try to stabilize before leaving the hospital of origin and want to be satisfied with all treatment parameters, prior to transport, so that the trip goes as smoothly as possible."

The infant clinical situation and need for transport can vary, depending upon each individual patient scenario. Annika Schön of the PETS staff has seen different situations throughout the years. "Usually we receive a request for consultancy from another hospital in Sweden, where they might have a case that has a difficult clinical situation, most frequently a child with respiratory insufficiency that is difficult to manage, and they ask for advice. In these situations, we may offer to take this child, with a difficult respiratory insufficiency, to be transported to our center for treatment. Other diagnoses may include sepsis, meningitis, lung disease or perhaps an infant with cardiac difficulties. All of these infants are in need of qualified ventilatory treatment. We also have cases of children receiving Extra Corporeal Membrane Oxygenation or ECMO, which need to be transported, or returned to their home hospital post ECMO treatment. Many of the children with cardiac difficulties have been born with abnormalities and are in need of heart surgery in specialist hospitals in another part of the country. We should also mention here that the infant pod has also been used for children up to 6-8 kilos."

Carina Ramstedt of Swedish Air Ambulance concurs. "We fly everything between short 30 minute 'jumps' to up to 3 hours, with infant transports. Our most frequent route is Stockholm – Malmö, 1 hour and 15 minutes for infants needing heart surgery at Lund University Hospital. But flight length depends upon the destination; to Ireland or other parts of northern Europe it may be 2.5 to 3 hours, and to different regions of Sweden it might be 1-2 hours."

Among the longer range flights, we have been to Paris, France where there is a radiologist who is a specialist on birth deformities in infants. When we fly to Dublin, Ireland or to Germany it may be in connection with ECMO cases. Usually these infants are transported post ECMO treatment, and in some cases we have accompanied children to Germany for treatment when the ECMO facility in Sweden has had no available capacity."

The infant transport process – meticulous planning and mobilization

Staff members from PETS and Swedish Air Ambulance are required to follow detailed routines and checklists at each institution, prior to transport. The PETS team members take about one hour to mobilize, from the point of contacting medical staff at home, who initiate the preparation process on the way to the

hospital, depending upon the patient situation. According to Dr Hamrin, the same routines and checklists are followed, whether the patient transport is land based, helicopter or fixed wing aircraft. "We have different partners for each alternative, and we always choose the appropriate transport alternative depending upon the patient situation. We receive a call from a referring hospital, often from an intensive care physician, and we find out as much as we can about the clinical situation; which medications the child has received, type of ventilation therapy, drains and which infusion pumps are being used. This gives us a picture of the situation in regard to what we need to bring with us for this particular patient."

"We have a transport inventory where we keep our equipment, and where we have packed and sealed transport bags for different patient age groups; newborn infants, small children and teenagers that are almost fully grown. If the child is receiving a certain type of medication that we normally do not keep in inventory, we make sure that we have it with us. We keep a standard assortment of materials in the bags, which are always filled and on stand by, but there can be special needs to customize in special situations. We test all equipment before we leave, see that the batteries are charged for the monitors and infusion pumps, and anything that runs on electrical current. We also double-check if we need oxygen or NO with us.

These preparations are mainly logistical, but critical for us to ensure that everything works as smoothly as possible when we receive the child. It is an advantage that we have a relatively small size working group, and once you have done a certain number of transports, the logistics become routine fairly quickly. When we return to our hospital, we complete the patient records and equipment log sheets, and see to it that the equipment is in good working condition for the next transport, we refill the bags and inventory to replace anything that has been used. The bags are then sealed so the next staff members on the next transport can feel confident that everything is in order." Routines and checklists are also carefully followed by the Swedish Air Ambulance group, according to Åsa Englund: "The care team is a combination of PETS staff members and the aircraft staff, or 3 persons in total. One aircraft nurse, who is an anesthesia nurse responsible for the cabin and the equipment and safety within the aircraft, and one PETS nurse, who can be a pediatric anesthesia nurse or a pediatric intensive care nurse, and one pediatric anesthesiologist from PETS accompanies the patient. Usually there is no room in the aircraft for family members, who have to make the trip on a commercial flight. Each transport situation is unique and requires careful preparation, in terms of the flight and the patient. We follow thorough and detailed checklists."

Annika Schön, RN, has been part of the PETS group at Astrid Lindgren Children's Hospital from the very beginning.

Prepared for any eventuality

In attending to infant care in flight, the noisy environment can often be a challenge in a fixed wing aircraft and especially on helicopter flights, according to Annika Schön. "It can be problematic to hear equipment alarms during flight, which means that it is especially important that the user interface has a good and clear visual display."

As an anesthesiologist, Dr Hamrin addresses additional challenges in treating ventilated infants in transport. She says that the worst case scenario would be an accidental extubation and losing the airway, requiring re-intubation. "Fortunately this has never happened to us. Another negative case scenario would be cases with diaphragmatic herniation with high airway pressures, where there is a risk of pneumothorax, but fortunately that has never happened to us either. However, we do plan and prepare to be able to handle any type of situation." The new technology and solutions have also contributed to minimizing these risks.

Intensive care transport trends in future

Representatives from both groups shared the opinion that the trend for air transports of ventilated patients will continue to grow in the future. In regard to the infant transport solution, Annika Schön feels that there is still potential for further development of the concept. "The next step is perhaps a bit larger stretcher for larger children, where the ventilator can also be mounted to serve as a one unit concept. And developments for weight reduction will continue to be important – weight is always a factor for consideration in air transports."

Åsa Englund expressed that the limitations of current land based ambulance models will continue to be a factor for increases in air transports. "I believe that the number of transports will steadily increase, even in the adult patient category. In terms of adults, there is a problem today that conventional ambulances are limited and cannot transport intensive care patients, and there are very few mobile ICU ambulances that are equipped and tested."

Dr Hamrin cited the needs of continuing development and the increasing focus on centralization and quality care in transport as important issues for the future. "There is a need for continued development. Weight and space are always important issues in transport situations and will continue to be so. Alarms can be difficult to hear in the air, especially in helicopters. This means that we continuously need to keep our eyes on the user interface screen, and to be able to see the screen values and alarms clearly."

"There is an increasing tendency to centralize specialized treatments at certain centers, which means an increase in the need for patient transports. There is a movement to more and more quality care during the transport. I think that if you are going to transport intensive care patients, by whatever means, the goal must be to provide the same level of intensive care treatment, and not to accept a lesser level of care during the transport, after receiving the patient. That simply is indefensible." ■

Biography

Tova Hannegård Hamrin received her medical degree at Karolinska Institute, Stockholm, Sweden in 1990. Her internship and residency in Anaestesiology and Intensive Care took place at Sundsvall Hospital, Sweden 1990-1994. She was certified as a specialist of Anesthesia and Intensive Care by the Swedish National Board in 1998 and worked as a specialist at Stockholm South Hospital, Sweden from 1994-2001. Dr Hamrin was Specialist in Paediatric Anesthesiology and Intensive Care from 2000 to 2007 at Astrid Lindgren Children's Hospital, Karolinska University Hospital, Stockholm, Sweden. She currently holds the position of Director, Paediatric Anaesthesia at Astrid Lindgren Children's Hospital and has been responsible for the PETS (Paediatric Emergency Transport Service) program from 2005 to the present time.

Annika Schön obtained her initial nursing degree in 1986, and worked initially in the adult intensive care unit of St. Göran's Hospital in Stockholm. She received her nursing degree in anesthesiology at the Karolinska Institute University Hospital in 1990-1991, where she also worked within the central anesthesia clinic, as well as within intensive care in the ambulance service at that institution. Annika Schön has held positions within pediatric intensive care at St Göran's Hospital since 1995 and at the Astrid Lindgren Children's Hospital in 1998, where she has been part of the PETS (Paediatric Emergency Transport Service) group from the start. Annika Schön is also currently working to achieve her PhD degree at the Institute for Women's and Children's Health at the Karolinska Institute.

Åsa Englund received her initial nursing degree in 1987, and her nursing degree in anesthesiology in 1993. She was employed as an emergency room nurse at the Halmstad Community Hospital in 1988 and as an anesthesia nurse at the Varberg Community Hospital in 1993. During the years of 1999-2000, Åsa Englund was employed as registered nurse on an international cruise ship, with nursing responsibility for guests as well as for fellow staff members from over 50 countries.

Åsa Englund started working at SOS Flygambulans (currently named Svensk Flygambulans – Swedish Air Ambulance) in 2001 as head nurse with responsibility for 15 nursing staff members. She became Operations Manager for the company in 2006, in charge of over 30 staff members and responsible for the medical department, marketing and property and operations. Åsa Englund became acting Managing Director of Swedish Air Ambulance in 2007. In this capacity she is currently responsible for corporate accounting, PR, marketing and chief of staff, and is a member of the management group as well as the board of directors. She also retains overall responsibility as Ambulance Chief for the flight planning center and medical departments.

Carina Ramstedt obtained her initial nursing degree in 1973 and her nursing degree in anesthesiology at Uppsala University Hospital in 1976. From 1976 to 1986, Carina Ramstedt was employed as a nurse at the Pediatric Intensive Care Unit of Queen Silvia's Children's Hospital in Göteborg. She has also worked as an ambulance nurse as well as nursing positions within coronary care and neurosurgical departments. Carina Ramstedt was also employed by the Swedish Defence Department as a field nurse with assignments in Lebanon in 1990 and in Bosnia-Herzegovina in 2000. She is currently employed as Flight Nurse at Swedish Air Ambulance, where she has been working since 2001.

Symposium faculty members included Christer Sinderby, PhD; Ivan Herold MD, CSc; Arthur S Slutsky, MD, PhD; Jesus Villar, MD, PhD; John Marini MD, PhD and Rolf Hubmayr, MD, PhD.

ARDS – Pathophysiology, Detection and Therapy, a symposium summary report

More than 100 critical care delegates from over 20 countries gathered together in the beautiful city of Prague, Czech Republic on two bright summer days in early June to attend the seventh and latest MAQUET World Class symposium. The preceding symposia include such venues as Monterey, California; Strasbourg, France; Shanghai, China; Mumbai, India; and New York City.

Chaired by Professor A.S. Slutsky of the University of Toronto and St. Michael's Hospital in Toronto, the distinguished panel of speakers included Vladimir Cerny, MD, PhD, FCCM of the University Hospital Hradec Králova, Czech Republic, Ivan Herold MD, CSc of Klaudian's Hospital, Mlada Boleslav, Czech Republic, Jesus Villar, MD, PhD, FCCM from the Hospital Universitario Dr Negrin, Las Palmas de Gran Canaria, Spain, Rolf Hubmayr, MD, PhD of the Mayo Clinic College of Medicine, Mayo Research Foundation, Rochester, Minnesota, John Marini, MD, PhD of Regions Hospital, St. Paul, Minnesota, and Christer Sinderby, PhD, Faculty of Medicine, University of Toronto and St. Michael's Hospital in Toronto Canada. Each presentation was followed by panel discussions, with interactive exchanges between faculty and participants.

Chairman Arthur S Slutsky, MD, PhD opened the two day scientific symposium.

Arthur Slutsky opened the symposium by outlining the background of exciting developments in mechanical ventilation during the past 10 years, reflecting the shift in philosophy from maintenance of normal blood gases to minimizing ventilator induced lung injury, VILI.

He defined the meeting goals of increased understanding of pathophysiology of ARDS and understanding of mechanism and importance of VILI, with an indepth look at basic mechanisms and clinical approaches in regard to acute respiratory distress syndrome, or ARDS.

Specific issues to be addressed in the meeting included contribution of biophysical injury to the development of biotrauma, definitions and inclusion criteria for clinical trials and limitations thereof, molecular mechanisms and vascular mechanisms in relation to VILI, current ventilator strategies for ARDS, and future ventilation strategies including Neurally Adjusted Ventilatory Assist – NAVA.

Contribution of biopysical injury to the development of biotrauma

Professor Slutsky presented information on how biophysical injury such as shearing, overdistention, cyclic stretch and intrathoracic pressure can lead to alveolar-capillary permeability, upregulating the production of many proinflammatory substances affecting cardiac output and organ perfusion. The subtle injury induced by these mediators released into the general circulation presents a pathway for secondary organ injury and failure, ultimately leading to death. Early institution of a protective lung strategy is critical, according to Professor Slutsky.

Do inclusion criteria control the outcome in ARDS trials?

Jesus Villar, MD, PhD reviewed several well-known ARDS outcome studies and problems with definitions. The international consensus definition of ARDS as per the AECC definition captures widely disparate forms of ALI/ARDS. Dr Villar stated that the AECC critieria are too non-specific to identify a population at risk for prolonged respiratory failure and support.

Dr Villar proceeded to present a summary of the H.E.L.P. Study from Spain; an early PEEP/FiO_2 trial identifies patients with established ARDS. The study included 170 ARDS patients, with ICU mortality 33.5%, after 24 hours on PEEP > 19 cm H_20 FiO_2 > 0,5, subcategories were defined as 16 ARF with P/F = 370 +- 54, mortality 6.3%, 55 ALI with P/F = 246.5, mortality 20% and 99 ARDS P/F = 155. l8, mortality 45.5%. Conclusions and implications of the H.E.L.P. study stated that the AECC definition for ARDS does not identify a group of patients with established ARDS, and that the use of these criteria has resulted in considerable disparity in severity and clinical course of enrolled patients, as the AECC definition for ARDS underestimates ARDS mortality and overestimates ARDS incidence.

Inclusion criteria for ARDS studies vary

widely. This makes the results from different studies hard to compare and even more difficult to give a prognosis of the outcome of an individual patient.

Dr Villar showed that, by a test with fixed ventilator settings performed twice with a 24 hour interval clearly identified three groups: One group with a PaO_2 / FiO_2 > 300 (ARF) had a mortality of 6%, a P/F ratio between 200-300 (ALI) had a mortality of 20% and a last group (ARDS) had a mortality between 50-60%.

Cellular stress failure in ventilator injured lungs

Rolf Hubmayr, MD, PhD outlined various examples of cell wounding and repair in ventilator-injured lungs. He stated that plasma membrane stress failure is an important mechanism in the pathogenesis of VILI and that most injured lung cells repair plasma membrane wounds, but failure to repair plasma membrane wounds results in cell necrosis. Successful repair of plasma membrane wounds is associated with a pro-inflammatory gene response, and exposure to a hypertonic environment appears to be cyto-protective and promotes cell repair in a variety of experimental systems. Dr Hubmayr also summarized that putative mechanisms include strenghthening of adhesive plasma membrane/ cytoskeleton interactions, increased yield/fracture stress of cortical CSK, and increased plasma membrane reservoir.

ARDS in the Czech Republic – current ventilator strategies

Vladimir Cerny MD PhD presented an overview of respiratory care in the Czech Repulic, including current national key principles and recommendations for ventilatory support in ARDS patients.

In a national survey in 2004, key ventilatory modes used were Pressure Control and Volume Control ventilation, and in weaning the modes of Synchronized Intermittent Mandatory Ventilation and Pressure Support ventilation were used. The key principles and recommendations from the survey include target tidal volume 6 ml/Kg body weight, target of an initial upper limit of plateau pressure < 30 cm H_2O, to allow hypercapnia if needed to minimize plateau pressure and/or tidal volume, to set PEEP to avoid extensive lung collapse at expiration and atelectasis, to consider prone position in patients requiring high levels of $Fi0_2$ and/or plateau pressures, and unless contraindicated, patients with ARDS should be maintained semi-recumbent. He also presented a national study survey from March 2008, with a conclusion that ARDS incidence in ventilated patients was 8%, that ventilatory settings in most patients follow current recommendations, and that there was low national use of rescue measures.

Symposium faculty speakers Vladimir Cerny, MD, PhD and Ivan Herold, MD, Csc of the Czech Repulic.

Lung protection in acute respiratory distress syndrome. The neglected vascular side

In his presentation, John Marini, MD, PhD stated that risk for VILI is proportional to transaveolar pressure applied to lung, and that such modifiable co-factors including position, minute ventilation, vascular pressure and temperature are important in the expression of VILI. In almost every paper on VILI there is concentration on tidal cycle: tidal volumes, plateau pressures and PEEP, but the vascular side is generally neglected. As the lung is distended, the blood vessels at the alveoli may act differenty than the interstitium. The capiliaries are compressed, and stresses differ within the capillaries, if the capillary has not had time to adapt to the pressure it has been subjected to, ie airway pressure. Dr Marini stated that microvascular events impact VILI, and that vascular dynamics have the potential to modulate VILI. He outlined that increasing the hemodynamic pressure gradient across the lung's micro-vessels worsens VILI, and if tissue stresses are sufficiently high, increased respiratory frequency and/or minute ventilation may worsen VILI. Reducing oxygen demand and ventilation targets may lower the risk for VILI.

The symposium presentations were followed by interactive discussion exchanges between faculty and participants.

Genetic determinants of sepsis – Multidisciplinary Organ Dysfunction Evaluation Research Network (MODERN)

Jesus Villar, MD, PhD summarized that contributors to variation in disease risk comprise many factors, including unknown factors 35%, environment 30%, ethnic 1%, age 4% and that genetic factors represent 30%.

SNPs in particular genes can be translated into genetic markers that ultimately act as predictors for the clinical outcome. Dr Villar stated that genomic science will modify 3 features of medicine; the nature of the disease (identification of susceptibility genes and innate risk), the perspective on disease (including a new class of individuals), and the social and cultural context, including genetic "tribes". He summarized that tissue sample can provide disease models, DNA array, pathology and treatment, and that outcome with pharmaco genetics to determine non-responders and responders will lead to individualized treatment or personalized medicine.

Limitations of clinical trials in acute lung injury and acute respiratory distress syndrome

In his introductory remarks, John Marini, MD PhD stated that we all depend on the results of clinical trials, which are in fact an experiment conducted on patients. And that he is extremely concerned that we are overdependent on this methodology. He stated that there are two views of randomized trial: bright pathway to new understanding and knowledge, and one of darkness.

Dr Marini stated that valid reasons for conducting randomized clinical trials may be to characterize the overall or collective result of applying a certain therapeutic strategy across a population of patients by caregivers with varying practice styles, or to confirm a consistent difference between therapeutic options and alternatives already in use in well-defined clinical practice environments. One additional valid reason might be to test in the clinical setting a promising approach with a solid pre-clinical research base.

He defined the ideal clinical trials as having sharply defined populations, to include testable questions and a well designed mechanism driven protocol-preferably a single mechanism at work with appropriate outcome variables chosen and a high impact intervention to be tested. He included other factors such as flawless methodology, tight co-intervention controls, unbiased data collection and analysis, and relevance to the practice of the indivdiual caregiver and patient.

When referring to the dark side of randomized clinical trials, Dr Marini expressed that evidence based medicine in managed care has became a force in the U.S., where evidence based medicine and managed care shared a common focus on outcomes measured across populations. The inferences of both for the individual tacitly assume precision of definitions and uniformity of response. In ICU practice there are no uniform patients, or precision of definitions, especially in ARDS. At best, population-based randomized controlled trials give guidelines, and not instructions or recipes for individual patient care, but unfortunately that is not the way they are interpreted at present. Dr Marini stated that standardization works well for industry, with uniform materials, and a perfected process to result in a uniform product.

Christer Sinderby, PhD, presented the concept of NAVA from brain to breath and the aspect of neuro-ventilatory coupling in health and disease.

In contrast, conditionally important factors in VILI are frequency, minute ventilation, position, $PaCO_2$ and pH, vascular pressures, temperature and other factors such as dP/dt (inspiratory flow) and I:E (adverse tension-time product). Other factors also include patient susceptibility such as genetics, timing of insults and interventions. In ARDS there is a situation of diversity and responsiveness: underlying etiology, identification accuracy, severity, pathophysiologic expression, regional mechanics, evolution over time, background co-morbidities and co-interventions determine response to therapy.

Dr Marini also stated that complexity and dynamism cause big problems for all types of clinical trials in critical care – we often treat syndromes not diseases, inherent population variability, multiple intersecting disorders of physiology, varied multi-element support influences outcome, susceptibility is often time dependent (time course of regulation). We cannot standardize most therapies effectively – to treat the individual we need short loop feedback based on patient response and frequent mid-course corrections.

In summary, Dr Marini recommended that in order to improve randomized clinical trials in ARDS, many factors must be carefully considered, such as testing the right question with the right intervention, better definitions of deadspace, lung size, compliance, and to account for timing of disease susceptibility and intervention effect. He also recommended selecting the patients wisely: confirm category, apply a test to categorize, consider comorbidity and co-intervention control, to design the protocol according to best mechanistic principles, and finally to interpret the results with caution.

Respiratory monitoring tools in determing patient-ventilator interaction

Rolf Hubmayr, MD, PhD presented a number of tools and variables in respiratory monitoring that may be used to determine patient-ventilator interaction. Many of these tools and variables are commonly used, and several are gaining acceptance in the critical care community.

His outline of respiratory tools and variables including ventilator waveforms, esophageal manometry, thoracic gas volume, venous and arterial pressure, gas exchange, lung imaging, lung sounds, and respiratory muscle electromyography.

Principles of non-invasive ventilation – The Czech perspective

Ivan Herold, MD, PhD presented recent data from observational co-hort studies about use of non-invasive ventilation in ARDS, including recent studies by Massimo Antonelli showing improved survival, reduced complications like pneumonia and sepsis, shortening the time on mechanical ventilation and ICU stay.

Symposium participants proceeding to a gala dinner after the first day sessions.

Dr Herold summarized the Respiratory Care Czech Study 2008, a single day ICU survey study of occurrences of ARDS and non-invasive ventilation. Non-invasive ventilation was used on average in 10.4% of ventilated patients, and 41% of ventilators in use in ICUs in the Czech Republic are designed for use of non-invasive ventilation. The survey also indicated that non-invasive ventilation is used frequently for short periods post-extubation.

Neurally Adjusted Ventilatory Assist – Why should the patient decide?

Christer Sinderby, PhD, introduced the significance of patient-ventilator interaction during NAVA and other modes of assisted ventilation by reviewing the literature of reduced time on mechanical ventilation in regard to daily spontaneous breathing trials and daily interruption of sedatives. He also reviewed a study investigating both aspects of daily interruption of sedatives and spontaneous breathing trials (Girard et al Lancet 2007) resulting in less time on ventilation in coma, in ICU and in hospital and lower cost and less likelihood to die 1 year after hospitalization. He also presented the literature indicating prevalence of ventilator asynchrony:

– 25% of pts > 10% asynchrony *(Thille et al ICM 2006)*
– 58% of pts > 31% wasted inspiratory efforts *(Chen et al CCM 2008)*

Dr Sinderby presented the concept of NAVA from brain to breath, and the aspect of neuro-ventilatory coupling in health and disease, as well as the aspect of muscle respiratory weakness in the ICU from a recent study (Sinderby, Beck, Clin Chest Med 2008) in regard to response by means of neural feedback.

Dr Sinderby also provided a detailed description of the features of NAVA: the Edi trigger, Edi assist, Edi cycle-off, and relation to PEEP, followed by a review of a study by Spahija et al of NAVA versus Pressure Support ventilation in patients with ARF.

In the conclusion of his presentation, Dr Sinderby outlined ongoing and future research in regard to NAVA. He presented a demonstration of increasing open NAVA level in an open chest model, as well as non-invasive NAVA in an animal model consisting of a severe acute lung injury in a sedated rabbit with non-invasive NAVA using a single tube inserted 2 cm in one open nostril.

Final Summary

Professor Arthur Slutsky gave a final summary after two days of lecture sessions and panel discussions. He stated that the ICU community understanding of VILI has increased substantially over the past few years, and suggests novel approaches to mitigate VILI, such as treating biotrauma, and physiological approaches including stress index, and NAVA.

***Flash versions** of the symposium lectures may be viewed by registered users at www.criticalcarenews.com - Lecture Library.*

Want to learn more about
Neurally Adjusted Ventilatory Assist - NAVA?

NAVA is a new approach to mechanical ventilation based on neural respiratory output. To learn the latest about NAVA as a revolutionary ventilation application and tool for neural monitoring, go to www.criticalcarenews.com

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