Experiences with NAVA in pediatric intensive care patients
The pediatric intensive care unit of The Queen Silvia Children's Hospital in Gothenburg, Sweden, is well known for applied clinical research in new therapies in Scandinavia. The PICU is one of the first clinics in Scandinavia to evaluate NAVA – Neurally Adjusted Ventilatory Assist as a new method of ventilatory assist of their small patients. Critical Care News was honored to observe this new generation of ventilation therapy on a ten-month old girl, who under post-operative sedation, was assisted by signals from a catheter to her diaphragm.

Critical Care News spoke with Karl Erik Edberg, MD, PhD, internationally known researcher and lecturer in regard to ventilation therapies, about the experiences with the first series of patients treated at Queen Silvia with this new generation of ventilation therapy.
Can you tell us about the patient who was treated with NAVA while we were visiting today?

The patient weighs 8 kilos and has a ventricular septum defect, as well as a pulmonary stenosis and abnormal pulmonary circulation attributed to a MAPCA-vessel (major aorto pulmonary collateral artery). So the case has been quite complex, but in an otherwise healthy patient. She underwent surgery yesterday, and a Sanoshunt was placed between the right ventricle and the pulmonary circulation. More surgery will be needed in future, but these are the first surgical interventions. Post-operatively, there have been a few complications, as there may be in more extensive heart surgery procedures, but since yesterday afternoon she has been doing well, and her lung x-ray this morning was good. I considered her a good candidate for NAVA, and informed her parents about the method and the study, and explained to them that she was a suitable candidate for weaning with NAVA. Prior to implementing the NAVA protocol, she was hemodynamically stable and on SIMV/PS, with 60-100% oxygen. During NAVA, she has been a model patient; she has generated her own breaths and Edi signals have been sensed in an exemplary manner and she was peaceful and calm throughout the procedure. We were even able to pull the chest tube aided by a small dose of alfentanil during NAVA. I anticipate that she will be extubated shortly. (Editors note: This patient was extubated the same afternoon and was transferred from the PICU to a general ward the next morning.)

Before we speak more specifically about NAVA, can you give us a general description about your department, average number of patients and staff?

We have 10 ICU care stations, with the capacity of handling up to 13 patients if needed. We admit approximately 600 patients per year and our average ICU length of stay is less than 48 hours, which is remarkably short. The majority of our patients are under 1 year old, and a great majority of these are post-operative heart surgery patients. We take care of approximately 200 heart-lung patients per year, in addition to other surgical patients. In regard to staffing, we are about 20 physicians who share the responsibility, 24 hours a day and 365 days a year. In this group, there are 5 physicians who are working exclusively with intensive care, and the rest are bridging between the surgical theatre and the ICU. We try to specialize in the different areas of our rather broad spectrum of activities here. We work with 5-6 registered nurses per shift, and about the same amount of pediatric nurses and practical nurses per shift as well. We all work together in mixed teams.

Which types of patient situations do you most frequently encounter?

Primarily we see post-operative cardiac patients, but all sorts of pediatric intensive care patients as well; sepsis cases, encephalitis, meningitis. We have patients with renal insufficiency and failure in need of dialysis; we also have patients with congenital birth defects such as diaphragmatic hernias, oesophageal atresias and gastrochisises in both newborns and premature infants. We also have patients with metabolic problems, severe seizure cases for diagnosis and treatment, trauma and accident cases such as poisonings, burn patients and drowning. For all cases here in general, the relationship between post-op patients and other ICU patients is 40/60%.

How are family member visits encouraged in your PICU environment?

As we observed during the NAVA case today, parents are welcome and are considered part of the PICU environment. We welcome parents at any time, day or night, and encourage them
to participate and be close to their children, and to observe treatment and care here. We try to encourage the parents to sleep at night, preferably away from the patient care area, and if they are living outside of the city, we try to arrange for accommodation in a facility close to the ICU building. Both parents are usually present for most patients, and siblings are also welcome. The only time where we actively encourage parents to leave their children is a rest period between 12 and 1 p.m each day. This traditional rest period is something we have established for many years, to offer the children a chance for as much quiet and as little disturbance as possible. During this period we dim the lights, and try to minimize procedures and traffic in order to provide peace and quiet.

When did you become familiar with the concept of NAVA, and what were the primary factors leading to the initiation and testing of this therapy at your center?

I became familiar with the concept of NAVA for the first time in Montreux 2004, when I heard Jennifer Beck speak about Neural Adjusted Ventilatory Assist. I was aware of the ongoing research, and read the literature that was published on NAVA at that time. I became personally interested in this methodology, since I am an ICU physician who has always had a special focus on pediatric ventilation. My doctoral thesis focused on lung mechanics and ventilation of premature infants. I was actively involved in HFO research, and was one of the first to introduce the HFO concept here in Sweden a number of years ago. I have also been involved in early research in treating infants with surfactant, and was first to introduce natural surfactant treatments in infants in Sweden, before surfactant became commercially available. I was also among the first to research and implement nitric oxide therapy, as well as non-invasive ventilation therapy for infants in Sweden. So, when NAVA became available for investigational use, naturally my colleagues and I were quite eager to try it.

The ten-month old infant patient whom we observed today, is the thirteenth patient you have treated by means of NAVA. How would you summarize your general experience with the method this far?

Primarily, that this method works very well, and we see that the children are doing well with it. It has become easier to apply and initiate NAVA with each consecutive patient. One extra pleasant surprise we have experienced is that over half of the children treated with NAVA have gone straight from NAVA to extubation. This surprise was a little unexpected, since the expectations we had when we started working with NAVA and traditional ventilation therapy were such that we thought we might expect that these children would be extubated within a day or so after the completed NAVA protocol. But when we have applied NAVA and observed that the pressures generated by the children have become so low that the children are basically breathing spontaneously, we have gone to extubation, without any complications.

In terms of the ventilator program with NAVA that we were using, the method works well for the patient, but there were some initial difficulties for us as caregivers with monitoring and alarm functions. These functions had been developed for traditional ventilation therapy, and not for NAVA, which means there have been a lot of redundant alarms, which were irritating at bedside. Our input has contributed to an improved algorithm. Our experiences helped contribute to tailor these functionalities. In regard to our specific experience with the NAVA patient you observed today, I would say she was a textbook case, in that her lungs were in good shape, she was lightly but adequately sedated without pain, and was quiet and peaceful, and very appropriate for NAVA as applied to the research protocol we are currently running.

Are there some specific patient experiences that are of special interest?

The youngest patient weighed 3.2 kilos and was just a couple of days old; however the age and weight of the patient are not critical in regard to NAVA. It is important to consider extremely premature infants with unstable breathing patterns and periods of apnea, where NAVA might be complicated. But for the great majority of our patients, maybe with the exception of babies with extremely sick lungs where our NAVA experience is too limited, NAVA can be an excellent method. I think for the majority of our post-operative cardiac patients, NAVA will be very beneficial and appropriate.

We have experienced NAVA with different patient cases with varying treatment times, from a couple of hours to one case that was treated up to 6 or 7 hours, and ended with extubation. In considering that we have had 13 patients so far, I think we have gained a broad experience with different situations. One of our patients weighed about 50 kilograms, and had severe lung disease, but we treated her with NAVA, which went exceptionally well. The pressures that we determined for her in Pressure Support were about the same levels that she generated herself with NAVA, but it was she who was driving her ventilation therapy and it went extremely well, despite the fact that she had very sick lungs.

We had one especially interesting case with a patient with a diaphragmatic hernia, who had received surgery here two years ago. The child returned with a recurrence of the hernia in the same area and needed new surgery. Earlier, we have been a little skeptical if a child with a diaphragmatic hernia could be treated with NAVA. But the therapy worked extremely well in this patient. We have had some patients where we have been uncertain in regard to their diaphragmatic function, including one patient who underwent neurosurgery for a tumor located in a portion of the brain where the respiratory centers are located. We had concerns that the respiratory center and respiratory regulation would be affected, and we were uncertain how the effect of the neurosignal to the diaphragm was functioning. But we provided NAVA in this patient, and it worked excellently. In fact, it was like a receipt that the patient’s connection from the respiratory center in the brain to the diaphragm was functioning normally.

In general, on the basis of our first experiences with NAVA, it is exciting to identify a number of research opportunities in the future. Previously, I have treated many extremely premature infants, often with surfactant, and for many years we have strived for the most gentle ventilation therapy possible, to avoid barotrauma and volutrauma. We have known for a long time that there are dangers associated with ventilating at high pressures, which we have tried to avoid. I see this as a potentially broad area for researching if NAVA can be used for children with different levels of IRDS; to determine if it will work, and if so, to see which pressures these very small children will generate to achieve their ventilation, and to see the significance of them directing their own breathing as much as possible. This is a large and exciting area that I am very curious about. I will be getting involved with our neonatologists who are working with ventilation of premature infants to see how we can utilize NAVA in these patients.

What is your practical experience with NAVA catheter positioning: in order to obtain the...
It has been a few occasions where disturbances have occurred, but there have been beautiful, harmonious, disturbance free Edi curves. In general, the Edi curve has been perceived as almost self-weaning for the patient. It functions in a manner where the less the patient-driven. I am convinced that this method will become very popular, when ICUs learn how simple it is, and see the benefits of it.

In a general ICU setting, what are the most significant initial pitfalls to be aware of or avoid in starting out with NAVA, with regard to your current experience?

It is important that the patient is somewhat stable, from a respiratory and circulatory perspective.

NAVA provides a potential to support bedside decision making, since in our experience, with support of the patient-generated pressure levels, it has contributed to early extubation of patients who we otherwise would not consider candidates for extubation. In these cases, we have been able to shorten the treatment time, as we have discovered that the patient was doing so well that we could discontinue ventilation treatment. Potentially, this means that lengths of stay in the ICU can be shortened, and costs can be reduced. I perceive NAVA as almost self-weaning for the patient. It functions in a manner where the less help a patient needs, the greater benefit the patient receives.

What, according to your experience so far, are the most important aspects for ICU staff to learn, prior to initiating NAVA?

First and foremost, it is important to truly understand the concept and with that, the realization that this type of ventilation therapy is very similar to the breathing patterns of children and adult patients when they are not on the ventilator, i.e. spontaneous breathing. There is variability in normal breathing which is rather large, and which is different from the very stereotypical conventional mechanical ventilation, where you set the size, frequency and mode of each breath in a very standardized manner. This traditional mechanical ventilation results in beautiful curves and loops that all look similar. This is not the case with NAVA; there is a big variation that is similar to spontaneous breathing. The other important aspect for staff to learn is to be meticulous in placement and function of the NAVA catheter, which needs to be re-checked every now and then. It is important to monitor the catheter periodically to ascertain that the catheter has not moved, for example if the patient has coughed, vomited, or has rolled around in the bed. It is very important that the catheter maintains the same position throughout the course of therapy.

These are the two aspects I consider to be of most importance to learn, but otherwise this is a very simple and uncomplicated mode of breathing, since it is so self-regulating and patient-driven. I am convinced that this method will become very popular, when ICUs learn how simple it is, and see the benefits of it.

In terms of experience after these initial patients, what do you perceive as the benefits of NAVA?

Our most definite experiences have been when we have perceived that we have given as much Pressure Support or SIMV as the patient required, we now realize that we have been giving too much. When we switch over to NAVA, we see by the Edi signal that the pressures being generated by the patient himself are substantially less than the pressures we had predetermined. We have simply been a bit too generous with pressures in the past in Pressure Support mode, which is our consensus after experiencing NAVA. When we return from NAVA to conventional respiratory therapy, we utilize this knowledge of the patient-generated pressures in NAVA, and we have treated with the NAVA pressure levels, and it has worked excellently. In any form of ventilation therapy where you can reduce airway pressures, reduce oxygen concentrations during ventilation therapy; all of these components are beneficial for our patients.

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Best ECG/EMG signals, how it is placed, when, and who positions the catheter as well as your experiences of administering NAVA and using the catheter as a normal feeding tube?

My experience is that this has been easy. We have been extremely careful to measure from the tip of the nose and around the ear to the lowest tip of the chest bone. We have made markings by using a separate catheter or the NAVA catheter. Placement has been confirmed very quickly in each case, mainly by means of the ECG. The catheter itself is very easy to place; it is moistened at the surface and is easy to get it down the esophagus, and simple to verify by means of stethoscope when it is in place. As a feeding tube, it works excellently for us, we have had no problems with this causing signal disturbance, and it is easy to evacuate air out of it. For the course of the evaluation, myself or another physician has been placing the catheter, however I am firmly convinced that in time this will be a routine assignment to other staff members, such as our nurses. In time, there will need to be other markings to indicate the center of the electrode array, and the distance is longer from the lowest electrode to the tip, which is placed in the stomach.

How do you perceive the Edi curve?

We have had some positive and some less than positive perceptions. We have treated a few children where the Edi curve has been perceived as a great jumble, difficult to comprehend and with a lot of disturbance. We have tried to adjust in order to get the Edi curve to present itself as we expect it to. But even if it has been jumbled, it has provided information to the ventilator so that the patient has received even and good tidal volumes. We have not had any case where the Edi curve has disrupted therapy, and we have always been able to treat the patient. And in some children, we have seen beautiful, harmonious, disturbance free Edi curves. In general, the Edi curves have functioned well, but there have been a few occasions where disturbances have taken place that have been difficult to identify.

Which ventilation therapies would normally have been used in these NAVA protocol patients?

We have utilized most of the modes that are available at present. The majority of our patients have received SIMV with Pressure Support, but we have also administered Pressure Control, PRVC, and Pressure Support with CPAP to some of our patients.

In a general ICU setting, what are the most significant initial pitfalls to be aware of or avoid in starting out with NAVA, with regard to your current experience?

It is important that the patient is somewhat stable, from a respiratory and circulatory perspective.

Parents are welcome in the PICU at The Queen Silvia Children’s Hospital.
perspective, and that the patient has the capability of maintaining his own respiratory capacity with help of his diaphragm. But in starting out with the method, I would initially avoid patients who have muscular diseases or a neuromuscular disturbance of any kind, or patients with brain damage or apnea tendencies. I would avoid these groups to begin with, and become familiar with the method first, before attempting to treat them with NAVA.

Which types of initial patient categories would you recommend others to start with, in order to gain experience?

I would recommend gaining experience with patients who are relatively lung-healthy; post-operative patients are a good category when they have come through their muscle relaxants and are past the heaviest levels of sedation, and are stabilized. I think that this is an excellent patient category to begin NAVA therapy with. I would start using NAVA in this category, and become more familiar with the therapy. After learning and becoming familiar with the therapy, it might be time to try it on other patient categories, such as muscular diseases, and diseases relating to the diaphragm, or brain.

Biography

Karl Erik Edberg, MD, PhD attended medical school at Umeå University during 1965-1972, and was employed as an anesthesiologist at Karlstad Hospital, Sweden in 1972. He specialized in anesthesiology and intensive care in 1977, and what was intended as a short stay at the Department of Pediatric Anesthesia and Intensive Care, Children’s Hospital (later The Queen Silvia Children’s Hospital) in Gothenburg, Sweden, is still ongoing. He was director of the department during the years of 1995 to 2004, and remains an ongoing consultant in pediatric intensive care at the institution.

Karl Erik Edberg was also appointed Clinical and Research Fellow at the Division of Neonatology, Department of Pediatrics at Vanderbilt University, Nashville, Tennessee during 1987-1988. A major research interest in lung function in the newborn led to a thesis in 1991 entitled “Lung Function in Newborns with IRDS.” Present research interests also include the clinical use of nitric oxide in neonatal and pediatric intensive care, and measurements of cardiac output in infants.

Karl Erik Edberg has served as organizer and invited speaker at numerous national and international meetings and congresses on pediatric intensive care. He was elected Vice President of the European Society of Pediatric Intensive Care in 1993, and was elected and served as President of the same society during 1995-1998. He served as Past President and member of the executive committee 1998, and was also member of the executive committee of the European Society of Intensive Care from 1995-1998. Karl Erik Edberg has also been a member of the board of the World Federation of Pediatric Intensive and Critical Care Societies from 1996 to 2004.

References


Critical Care News also spoke with Dr. Ola Ingemansson of Queen Silvia Children’s Hospital regarding his perceptions of NAVA during the clinical evaluation period:

What are your general perceptions of this new ventilation therapy at this point in the clinical evaluation?

During the NAVA sessions I have been involved in, I have observed that the majority of patients have been very calm and peaceful during NAVA, with the exception of one patient who had very sick lungs, and required very high pressures.

Based on these initial experiences, what do you think will be the advantages of NAVA, compared to other traditional methods of ventilation therapy?

I believe NAVA will be a very good therapy for weaning, and I believe it may lead to earlier extubation in the future.

How would you practically advise other ICU’s that are considering implementing NAVA as a new ventilation therapy?

Theoretically it is important to know how it works, the entire concept, before the institution initiates this new method of therapy. Secondly, you must be able to trust NAVA itself, which differs from other ventilation therapies. Our small patients are different, since spontaneously, they would like to breathe more frequently and with fewer big breaths. You also must realize that the airway pressures are very low, and accept this fact, and not worry about it. This experience with NAVA has led us to the realization that we have probably had higher pressures on the other ventilation modes, before we have switched over to NAVA, where the patient has required much lower pressures. For ICU’s that wish to start using NAVA, I personally would recommend starting out on post-operative patients who are hemodynamically stable and are close to extubation, since I believe this is the patient category where it is easiest to gain experience and confidence in the method.