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.

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.

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
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Professor Idrissi with PICU staff member Dr Willemijn Van Heel.

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 CO₂ is very low, the patient physiologically stops breathing. Our trigger is CO₂ 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 CO₂ 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 high oxygenation, 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 H₂O 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 CO₂ 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
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 Said 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
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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
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