VENTILATION
SERVO-i FOR NEONATES
SYNCHRONY FOR THOSE WHO NEED IT MOST
Respiratory support delivered asynchronous to the baby’s effort has been shown to increase the length of stay in the ICU and to prolong mechanical ventilation. Although fundamental to the baby’s comfort and outcome, the problem of asynchrony usually goes undetected and untreated. The opportunity to measure and display the electrical activity of the diaphragm (Edi) presents a totally new insight into how the baby’s respiratory regulation is affected by the disease, and how the baby is able to cope with the disease process from a respiratory perspective.

That is why the electrical activity of the diaphragm (Edi) should be regarded as a vital sign for mechanical ventilation. Edi provides information on patient effort, degree of assist provided by the ventilator and synchrony between the patient effort and the ventilator assist. Neurally Adjusted Ventilatory Assist (NAVA) offers an extension of the baby’s respiratory vital sign as NAVA uses the baby’s own biological signal for the generation of ventilatory assist in proportion to the baby’s own effort. The assistance provided is in synchrony with the baby, is insensitive to leaks and will unload the patient work effectively during both invasive and non-invasive ventilation.

The efficacy of the main respiratory muscles and the degree of respiratory demand determine the degree of respiratory center output. In a healthy baby, the low amplitude of diaphragm excitation (Edi) reflects the fact that the main respiratory muscle (neuroventilatory coupling) is highly efficient. Conversely, a higher deflection of the Edi signal indicates illness or disease. For a seriously ill baby with high deflection of the Edi signal, tidal volume VT may even decrease due to the bio-feedback protection mechanisms.
The paradigm shift in mechanical ventilation offered by NAVA is never so obvious as in small children and neonates. Patient-ventilator synchrony used to be difficult to obtain, unless the patient was heavily sedated or by administration of neuro muscular blockers, implying that synchrony could only be achieved if the baby was inactive.

Today, more than 25,000 patients have experienced the comfort and safety of NAVA. The experience shows that patients are more comfortable and able to control their own respiration unless there is a direct impairment of the respiratory centers. Clinical studies are confirming the benefits to patients by the improved synchrony of NAVA³.
SERVO-i FOR NEONATES
VENTILATING WHAT ISN’T THERE

Respiratory failure in newborns and premature babies is a reflection of the lack of preparation for the new environment. They lack alveoli, surfactant and a functioning chest wall. In addition, central respiratory regulation is not fully developed. Each of these issues creates its own problems. The surface area for gas exchange is limited due to fewer and immature alveoli. Airways tend to collapse due to surfactant deficiency. The lung itself tends to further collapse under its own weight due to the lack of a functioning chest wall. In reality, the baby will struggle during inspiration to fill the stiff, collapsed lung and fight during expiration to prevent the lungs from closing, further decreasing the gas exchange area. The immature respiratory centre causes central apneas, and if not managed, may lead to impaired oxygenation.

The baby is never allowed to rest!
Obviously, post-natal development will be impaired if all energy is consumed by the act of breathing. For the baby to thrive, the energy balance must be shifted.

If the respiratory muscles are weak or the respiratory load is too high for the premature baby to cope, the work must be distributed to or taken over by a mechanical ventilator. Logic states that to maintain and improve the function of the respiratory muscles, the load should be reduced to normal while the ventilator accepts the work induced by disease.

PRIMARY PROBLEMS IN NEONATAL VENTILATION

- Cardiopulmonary systems are not fully developed
- Chest wall is highly compliant with very stiff lungs
- The respiratory centers are immature
The breathing pattern of a newborn is highly irregular, with periods of apneas, sighs and rapid shallow breathing. This is a direct contradiction to the design of mechanical ventilators that function by the delivery of fixed tidal volumes, pressures and respiratory rates. The collision is unavoidable. The ventilator will deliver set volumes and pressures in direct conflict with the baby’s respiratory center output, both in terms of timing and size, leading to unnecessary high pressures with a distribution of high stress tension directly to the limited amount of healthy alveoli. The conflict is observed as failing gas exchange and severe respiratory asynchrony.

With the information provided by standard ventilation technology, it is difficult to determine if the ventilator is synchronized to the patient effort.

**NAVA – synchrony both in time and assist**

NAVA provides synchrony in both time and assist, reducing WoB and energy consumption. Provided by the proportional delivery of assist determined by the babies efforts breath by breath.
In fact, ventilator autocycling is often mistakenly interpreted as a fast trigger response (see fig). In contrast, the display of the Edi curve will give you an objective and immediately accessible tool to monitor the activity of the patient and the response of the ventilator.

NAVA WILL REDEFINE SYNCHRONY BREATH BY BREATH

- Decreases airway pressure by bio-feedback\(^3\)
- Allows the baby to rest and save energy for growing
- Improves oxygenation and CO\(_2\) washout\(^4\)

Circuit leak resulting in autocycling. No patient activity seen in the Edi tracing, resulting in passive filling of the lung.
Patient-ventilator asynchrony is unavoidable in small babies with current standard ventilator technology. However, assessing if and when to correct the situation is almost impossible, due to the high number of variables. The electrical activity of the diaphragm (Edi) is the compound representative of the respiratory centers. The reaction to patient-ventilator asynchrony can sometimes be dramatic and is fully visible by the amplitude and tonic activity replicated by the Edi signal (see fig).

Neonates do not have a stiff chest wall to protect the patency of the lung. The preterm conserves (FRC) lung volume through changes in RR and tonic activity of laryngeal and diaphragm muscles. This will often be reflected by a deviation of the baseline for the Edi, representing tonic activity of the diaphragm. This may sometimes be periodic, but in some instances stationary. This is a potent sign of serious collapse of the lungs during expiration. A stepwise increase in PEEP will usually improve the situation for the baby, sparing the work of the loss of lung volume during expiration (see fig).

The SERVO-i allows you to display the current output of the respiratory centers to aid in determining how the patient is coping with their respiratory load. The clinician can now monitor and set the ventilator to allow unloading of the respiratory work induced by the disease, with the patient assuming the fractional work representative of health.

Unloading with NAVA using the Edi signal

The Edi signal reflects the muscle strength of the diaphragm, the neuro-ventilatory coupling. By reading the Edi signal and observing the patient, a decision on the level of unloading can be made and subsequently managed by adjusting the NAVA level.
As the respiratory muscles improve and the disease subsides, the patient will essentially wean himself. This can be observed by the decrease in amplitude of the Edi signal and a maintained tidal volume. Weaning thus can be observed from the Edi, which replicates the improvement in respiratory muscle function and biological feedback control.

The origin of Edi. The Edi catheter, a nasogastric feeding tube with electrodes positioned at the level of the diaphragm, captures the electrical activity (1). The raw signals detected by the electrodes during one single inspiration (2). Filtered signals without the ECG signal (3). The signals closest to the diaphragm are selected for the strongest Edi (4). The final Edi signal used by the ventilator to assist the patient (5), which interprets and responds near-instantly with the proportional level of support for that breath (6)⁷.
SERVO-i FOR NEONATES
NON-INVASIVE VENTILATION IN A NEW WAY

Breathing is a well coordinated activity, which requires very little effort in health.

The diaphragm, laryngeal and chest wall muscles work in concert to augment the function of every component, thereby protecting the fragile tissues in the lung from the damage of a hostile environment.

Incorporating SERVO-i with NAVA into the same biological feedback loop as the one controlling the respiratory muscles means that coordination is fully controlled by the patient. The biological feedback is suddenly available to the clinician, whose primary task becomes to assess the distribution of respiratory work between the patient and the ventilator. Any change in this balance will be obvious as it will affect the feedback from the brain and thus the strength of the Edi signal.

Epiglottis. Traditional non-invasive ventilators or CPAP devices disrupt the natural synchrony between the epiglottis and diaphragm, making it difficult to swallow or eat. The neural triggering of NIV NAVA allows neonate patients to eat and swallow comfortably and safely. Breathing mechanism opens the epiglottis during inspiration synchronized with the diaphragm. Observations indicate that the lower esophageal sphinter muscle closes during inspiration preventing air leakage to the stomach, when synchronised with the diaphragm.

The natural respiratory biological feedback loop in synchrony with the artificial muscle of the ventilator controlled by the Edi signal originating from the respiratory center.

The coordination between airway opening and diaphragm electrical activity (Edi). Note how the airway is fully dilated only at the beginning of the inspiration (1). The airway is then closing to avoid over-distension of the lung (2, 3) The airway opening is not fully dilated during expiration to protect the end expiratory volume (4, 5).
SERVO-i for neonates

SHOULD THE PATIENT BE ALLOWED TO CONTROL VENTILATION?

Intubation is the most significant event related to the development of bronchopulmonary dysplasia (BPD). Data support efforts to avoid intubation and mechanical ventilation. There is a broad consensus that CPAP should be the first line of treatment. However, failure of CPAP is common, leaving only the option to resort to some form of mechanical ventilation.

SERVO-i with non-invasive NAVA opens a totally new spectrum of opportunities. Non-invasive NAVA can be administered with any patient interface best adapted to the patient. The sensing of the patient effort is no longer a problem, and inspiratory assist will be synchronized to the patient effort independently of the size of the leak. Intubation can, in most cases, be reserved for situations where there is an urgent need to protect the patient airway or for copious secretion.

The immaturity of the respiratory center is managed by the back-up system of the SERVO-i, which will react immediately to apnea by providing controlled breaths, and promptly return to NAVA when triggered by patient efforts. The decrease in Edi amplitude with maintained tidal volume will show improved efficacy of the respiratory muscles. Decrease in FiO₂ needs will show improved gas exchange.

WHY THE PATIENT SHOULD CONTROL THE VENTILATOR

- The patient will only receive the assist required, with the aim of achieving homeostasis.

Leakage independent

Excessive air leakage around prongs and masks challenges the ventilator’s ability to synchronize the assist to the patient’s needs. This is also the case for leakage related to cuffed and uncuffed tubes. NAVA is leakage-independent, calculating and correcting delivery of support instantly to overcome the leakage loss.

Automatic back-up

When the baby is apneic and the Edi signal is undetectable, the SERVO-i will automatically provide backup breaths until the Edi signal is re-detected and automatically returns to NAVA.
NAVA opportunities. Patient-ventilator synchrony is mandatory for small babies. This can be reliably achieved with NAVA. NAVA will also normalize blood gases and improve oxygenation\(^4\). By means of the back-up system integrated with NAVA, the risk of hypoxia is lowered, potentially reducing the need for controlled mechanical ventilation.

SERVO-i WITH NAVA OFFERS

- Synchrony independent of leaks
- Edi — a vital sign for patient assessment
- Neural control with automatic apnea backup
SERVO-i FOR NEONATES
ADAPTABLE TO YOUR CHANGING NEEDS

For more than 30 years, MAQUET has been a leader in setting mechanical ventilation standards with systems such as SERVO-i. Today, NAVA builds on that tradition by making true patient-ventilator synchrony possible, even for neonates.

The SERVO-i is a modular, ergonomic ventilator that can grow as your needs change. Designed for serviceability and upgradeability, SERVO-i will continue to let you take advantage of all standard ventilation modes, while facilitating changes to your configuration as your needs change or as innovations become available.

Essential for the non-invasive application in neonatal is the patient interface systems that must be designed for minimal dead space, weight and noise levels. The possibility to change between prongs and mask is of importance to avoid injuries.

SERVO-i delivers all standard ventilation modes in one compact, easy to use system with intuitive controls and intelligently-designed monitoring. It also features Y Sensor measuring, continuous nebulization and is available in MR, Transport and Heliox configurations.
NAVA is used in intensive care units in countries all around the world for neonatal, pediatric and adult patients. Clinical evidence for NAVA has been documented in multiple clinical studies in scientific peer-reviewed journals, a body of work that continues to grow exponentially every year.

Most aspects of both SERVO-i and NAVA are well-documented in a number of pocket guides, case studies, e-learning, training and support materials. For more information, ask your MAQUET representative or visit www.maquet.com.

Peer-to-peer forum for sharing NAVA experience
The magazine Critical Care News and its associated website, www.criticalcarenews.com is a forum hosted by MAQUET Critical Care for intensive care clinicians to share clinical experience of NAVA. The website is a primary source of user information about invasive and non-invasive NAVA, and contains up-to-date lists of clinical literature reference lists, patient case reports about the use of NAVA in neonatal, pediatric and adult patients, as well as numerous NAVA lectures and interviews with intensive care physicians about NAVA.

REFERENCES
Selected publications on the topic of NAVA in neonatal care:


For more comprehensive lists of scientific studies on the topics of NAVA, please refer to www.criticalcarenews.com and select topic under Reference List.
The product NIV NAVA may be pending regulatory approvals to be marketed in your country. Contact your local MAQUET representative for more information.

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