New opportunities for MRI examinations of ventilated ICU patients
Can you generally describe some of the challenges and difficulties you have encountered in this situation?

Like many other ICU departments, we struggle with the difficulties in MRI examination of ventilated ICU patients in certain specific patient categories. Our goal is to maintain ventilation therapy as safely and consistently as possible, to avoid interruptions to therapy in the process of transporting them to the MR department.

New opportunities for MRI examinations of ventilated ICU patients

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

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

We have had patients that we would have liked to examine by means of MR, but if they have high intracranial pressure, caused by meningitis, encephalitis, stroke or trauma, it is important to maintain ventilation with as little disturbance as
possible. But since this has been extremely difficult to accomplish, we have avoided MR examinations for some of these patients, unless there has been an absolutely acute need for it. The process up to this point involved switching patients to a transport ventilator, and then switching them over to a SERVO 900C in the MR area.

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

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

How important are MR examinations here at the University Hospital?

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

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

How will the new solution solve some of these obstacles?

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

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

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

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

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

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

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

In the past, we had ventilators in all three neurosurgical departments, and the anesthesiologist coordinated the ventilation treatment. The decision was made to establish a dedicated neuro ICU here at the University Hospital, since it was preferable to consolidate patient care and patient monitoring of the worst cases within one unit. In terms of patient categories, subarachnoidal hemorrhages are a category where we only see about 100 cases per year. We have between 50 to 70 severe neurotrauma cases per year, and
then there are more moderate forms of trauma that need ICU care as well. These patients with acute cerebral trauma can be challenging to treat with mechanical ventilation, as they are prone to develop neurogenic pulmonary edema and myocardial infarction. We also see a broad spectrum of other patient categories: stroke, meningitis, epilepsy, and tumor patients.

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

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

Maintaining a constant and steady CO₂ is important in the care of our particular patients. This means that many patients are treated with volume-controlled ventilation, however many of us have a preference for PRVC. Some of our patients are in the ventilator for longer periods of time before they can be weaned, and we usually switch over to Pressure Support in the weaning process.

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

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

I think so absolutely, we have research projects where we have a special interest within cranial trauma. We would like to conduct more research here, partially based on MR examinations that were not previously possible, since it was not optimal from a patient perspective, keeping control of pressures and other parameters.

Variations during ventilation for these types of patients are problematic. This new ventilation solution for MR presents us with an opportunity to measure new modalities like cerebral blood volumes, where we have measured CBF – cerebral blood flow in the past. With spectroscopy we have opportunities to learn about the chemical changes of the traumatized brain. There are many research opportunities, which have been constrained in the past from a clinical and research perspective, since the ventilatory aspects have been so difficult and limiting.
References


Biography

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

He has conducted research within the areas of rCBF changes during inhalational anesthesia in collaboration with the Clinical Neurophysiological department of Lund University Hospital, as well as evaluated the neuro-electrophysiological changes due to sedation - anaesthesia. Peter Reinstrup has also worked in research of normal and pathophysiological interstitial biochemical environment in the brain with microdialysis and evaluated its use in the ICU in order to improve cerebral cell survival, as well as evaluated the value of diffusion MRI in brain pathology. He is collaborating with Professor Bertil Romner in establishment and continued study of transcranial Doppler pulsatility index (PI) for non-invasive measurement of the ICP.

Peter Reinstrup has investigated the use of cerebral brain damage markers and measurement of CBV with the SPECT scanner in order to use MRI for the same purpose. He is currently working together with Dr Erik Ryding, Karolinska Insitute, Stockholm and Dr Erik Bloomfield of the Mayo Clinic in regard to a new technique to measure continuous globalCBF in the ICU.

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