The continuing development of neonatal and pediatric ventilation therapies
The very first pediatric intensive care unit in Germany was established at the Children’s Hospital of the Johannes Gutenberg University in Mainz in 1965. Ever since that milestone, the center has been involved in great advances in neonatal and pediatric research and patient treatments, which has led to rapid expansion and the establishment of the current interdisciplinary pediatric intensive care facilities. The institution recently celebrated its 40th anniversary by means of a two-day symposium with international experts. Critical Care News met with some of the staff members of this remarkable ICU, including Ralf G. Huth, Director of Pediatric Intensive Care.

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Can you tell us about your 40th anniversary celebrations?

Ralf Huth: The background story is quite simple: in 1965, the Director of Pediatrics had a job offer at the University Hospital in Frankfurt, and in the negotiating period, he established an emergency department here. This building was only intended as a provisional solution for five to ten years, but it grew and became well established over the years. This was the first pediatric intensive care unit in Germany, and the fifth in Europe. Our recent anniversary symposium was not only a celebration, but also an overview of what pediatric intensive care is all about, from disease and therapeutic perspectives. We reviewed not only disease situations but also the therapy options we have today, compared to the past and with a view to the future.

What has been your experience of ventilation therapy, in regard to past history as well as your future requirements?

Ralf Huth: If we review our own experiences in mechanical ventilation, we always used as a standard ventilator the old SERVO 900 device. But the problems with weaning meant that ventilation with infants was not that easy with this device. We were looking for another device. At that time there were only the old Draeger Babylog devices available. We then tested other ventilators; such as the Infant Star, the Engström ventilator and the Sechrist. We decided to go with the Infant Star, which in those days had the combination of flow-interrupted neonatal ventilation with the possibility of High Frequency Oscillation (High Frequency Flow Interruption HFFI). We had four devices aboard for neonates, and for older children we had Servo Ventilator 900 C.

This worked well in the early days. But when we moved to this new facility, we needed to redesign and that was the time that the Servo 900 C was getting older, and the Servo Ventilator 300 came on the market, so we would have a combination of treating even neonatal patients with the Servo Ventilator 300. The issue of weaning was important, especially when we started with pediatric cardiac surgery here in 1985. At that time it was necessary in controlled ventilation to start up with the Servo 900C, and when it was time for spontaneous ventilation we would switch to a neonatal ventilator. This subject was almost solved with the Servo Ventilator 300 as a very good device covering a large range of patients.

Non-invasive ventilation was not regularly in use at that time. We were the first center in Germany to try out HFO with the Sensormedics 3100A. Oscillation came for neonates, as well as high frequency jet ventilation. It was transferred to Europe, and increasingly used in neonatal and pediatric ventilation, but never connected with the adult patient population. As there was some interest in our anesthesia department, I tried to show the benefits of oscillating flow. At that time, we had a sophisticated system that provided nitric oxide in combination with HFO. In the adult departments, we came to help out with our equipment for the especially difficult cases, like the ARDS patients. I had an opportunity to take part in one of the first scientific and education symposia on HFO, and convinced some of my colleagues in the adult department to come with me. In a workshop with a lung lavage model in a big pig, HFO was initiated and you could see improvement and we almost understood how HFO could work. Normally technology comes from the adult sector to the pediatric, but in this case it was the other way around.

After this experience, we were then focusing on the neonatal and pediatric non-invasive ventilatory care. We found one device that was ready to do this at that time, the Hamilton Galileo that offered non-invasive ventilation and also automated ventilation or
Since the introduction of SERVO-i since this device offers the possibility of non-invasive ventilation in addition to controlled ventilation, even in the neonatal age group. Different ventilation treatments for all age groups combined in one device was the goal. Currently we have a problem with too many devices, and the storage rooms are too small. Ralf Huth: we would say, “this child needs ventilatory support” which automatically implied invasive ventilation. We were not secure about interfaces: masks, nasal prongs and the like. Gradually we got experience and saw that it could work. By introducing PEEP and opening the lung, we could also give these children support that was feasible by non-invasive measures, with less oxygen requirement, fewer ventilatory problems, and less exertion.

What types of patients do you most frequently encounter?

Dr Jan-Helge Höpner, pediatric intensive care physician: Our main focus is on pediatric post-cardiac surgery, or post-neurosurgery. We do have general surgical cases, and everything that comes otherwise: infections, oncology patient with ALI or ARDS, trauma patients (fortunately decreasing rates over the past years), orthopedic surgery, urological surgery, oro-facial deformities, and other birth defects. We have a separate burn unit for two patients.

How long have you been doing nasal CPAP therapy here?

Ralf Huth: Since the introduction of this therapy. Nasal CPAP therapy had a big impact on controlled ventilation with all the complications. We were among the first to introduce transcutaneous CO₂ measurements and transcutaneous O₂ measurements. Being early involved with nasal CPAP therapy, we then gathered additional information by non-invasive monitoring to know when to reduce invasive ventilation therapy and change to non-invasive ventilation. Previously, we were flying blind. I can remember in the past how we did blood gas analysis. I started at bed number one, finished at bed number ten and went back to bed number one again. What has changed from that time is the add-on information from non-invasive monitoring, like saturation monitoring and CO₂ monitoring. This gives us a sense of security when it’s possible to reduce invasive ventilation therapy and go over to non-invasive support.

In light of some of your experiences with nasal CPAP is there an advantage of being able to provide nasal CPAP and invasive ventilation therapy with the same equipment?

Ralf Huth: Yes – right now we have too many devices, and the storage rooms are too small. Offering combined therapies with the same ventilator is an advantage.

Susanne Frey, pediatric intensive care nurse: When there is a new patient coming, we have to decide which ventilator to use. If you have too many devices, you almost have to decide before you see the patient, which is difficult because we need to know if they will need non-invasive or invasive ventilation. If you have too many machines, it is difficult and time-consuming. Now we see the chance of choosing one device and doing pretty much everything with it. In Mainz we are looking for everything in one unit, from the newborns to the ninety kilo children, for the non-invasive and the invasive support.

How many different ventilators have you had in inventory, and as a nurse what are the challenges in training on these different devices?
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Susanne Frey: Plenty of models: the Infant Star, the Servo Ventilator 300, the Hamilton Galileo Gold, the Sensor Medics 3100 A and B with HFO, the Breas transport ventilator LTV 1000 and a CPAP device Vital Flow. This is a problem because if you get new staff members and you have to teach them on all different devices: Each model functions a little different, in terms of modes, and user interface. It is a challenge for the nursing staff. And each device model has special tubing, which requires training and logistical management as well.

Dr Höpner: It is also a challenge for the doctors. We need to decide which therapies the nurses should monitor. The other thing is that we physicians have to rotate between the different wards as well, which means that it is easier if there is some standardization - not only within the unit, but in our neighboring units, too.

Ralf Huth: The difference between the devices is a problem, which we are trying to overcome by finding one device that suits all. There are not only the technical aspects, but also how the user interfaces for these devices are designed for easy understanding and operating.

What are your experiences of combined invasive ventilation and nasal CPAP in the same ventilator? Can you share some of your patient experiences?

Susanne Frey: We have treated neonatal patients with ALI or respiratory distress using nasal CPAP and we have treated pediatric patients with muscular disease. We have treated post-op surgical patients with atelectasis, which have started out on invasive ventilation, before we have switched them over to nasal CPAP, as well as oncology patients with pneumonia. Different types of non-invasive therapy have been provided, depending on the situation. For instance, in some cases we only needed CPAP to maintain PEEP; in another situation we needed Pressure Support too. There is much that can be done with non-invasive therapies, and we have different patient interfaces available; nasal prongs, nasal masks and full-face masks.

What are the most important practical aspects for nasal CPAP therapy? Is it early application, fixation, or the fitting of the patient interface?

Susanne Frey: The system should be easy to use. The patient interface should fit the patient comfortably but avoid leakage as much as possible. We used a helmet in one girl with chronic myelogic leukemia, who in the course of chemotherapy had leukopenia and ALI/ARDS due to pneumonia with PEEP up to 15 cm/H2O. Initially she had an oxygen requirement of up to 100%, recovering under NIV. Oxygen was reduced to 30%. The non-invasive therapy with the helmet worked quite well in the acute situation.

Do you have a preference for the types of patient interfaces you are using with nasal CPAP?

Connie Sander, pediatric intensive care nurse: For the small patients (up to 5-6 kg), we use the prongs, which work very well in combination with the pacifier, which manages leakage nicely. For the larger children (bigger than 6 kg), we prefer to use a nasal mask, and in some cases a full-face mask is needed, depending upon the individual facial morphology. Or in cases where they are not fully awake and can keep their mouths closed, we use a full-face mask. We have used the Fisher Paykel nasal CPAP interfaces, and they worked very well since you have different sizes to fit the actual patient, no problems with long or short nostrils.

Susanne Frey: We did have one tricky interface problem with a patient on the SERVO-I. She had been intubated for a very long period, and after extubation, we saw a big difference in the size of the nostrils. This was one specific case that was a little tricky to manage, but we did it.

Ralf Huth: It may not be a matter of which of the interfaces to use, but whether we have the right interface for this new kind of ventilatory support? I would say that a center might want to re-investigate which types of interfaces they are using, since this new combined device for invasive and non-invasive therapy probably gives you some new necessities and possibilities.

I think that we are not yet at the end of discussions how the patient interfaces between ventilators and children are designed, but hopefully we will see continued interface development. Having a new ventilator on the market, providing different kinds of support, from invasive to non-invasive therapy and back again, may challenge development of interfaces with quality and ease of use, alarm management and patient comfort in terms of application for neonates and small children.

Dr Höpner: I think patient comfort is a very important issue equal to the ease of use. If it is easy to start up a device, but you need to go back and readjust it every half hour because the patient is awake and moving, you have really gained nothing.
How long have you had the latest combined ventilator for invasive and nasal CPAP therapy?

Ralf Huth: For about six months, in the recent version which we have been evaluating. We have just decided to purchase these units, which we consider an investment into the future. In my point of view, the development of SERVO-i was a straight line in development from the Servo Ventilator 300. It offered the same type of ventilation opportunities, but it was not a re-introduction of ventilation concepts; rather you could see a natural continuation in development. It was significant to us that SERVO-i included the combination of PRVC with SIMV, so that you have the possibility of this mode, which was not available before. This was something we were really looking for. I think the user interface was straightforward, with the easy access knobs to the most interesting parameters. The calibration of the O₂ cell facilitated ease of use. So I think that the development was going in the right direction, and it was very easy to introduce this device after long experience with the Servo Ventilator 300, compared to other devices we had been testing before. It was a logical continuation of development, which eased the acceptance of introducing SERVO-i into the ward, compared to other models.

We have one infant patient here who has been extubated after an operation. He was treated with SERVO-i for a long time. He has spinal muscular atrophy with pneumonia, which needed long term support. I think without the SERVO-i we would have had to intubate him, but we were able to easily switch from nasal CPAP to non-invasive ventilation. So we were able to keep him totally on non-invasive support, which is unimaginable with any other device we have had so far.

References


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