Challenges and developments in lung protective ventilation for neonatal and pediatric patients in Mumbai
Challenges and developments in lung protective ventilation for neonatal and pediatric patients in Mumbai

Balabhai Nanavati Hospital was inaugurated in 1950 by independent India’s first Prime Minister, Pandit Jawaharlal Nehru. Nanavati Hospital has grown from the original 50 bed, single building facility to the current five building complex with over 450 beds.

In 1962, Mother Teresa brought her first child to Nanavati Hospital for treatment, which marked the beginning of a longstanding relationship between her and the hospital. The state-of-the-art Blessed Teresa Advanced Paediatric Center was opened three years ago at Nanavati Hospital, and has treated over 5,000 children, with a survival rate of 94% in the PICU/NICU. They have a survival rate of 92% for children who required mechanical ventilation.

Critical Care News discussed these impressive results, and the difficulties encountered in a rapidly expanding and subtropical environment with Neonatologist and Pediatric intensivist Dr Hiren N Doshi, Program Director and his associate, Dr Suresh Birajdar.
What is the range of gestational age for the neonatal patients you treat?

Dr Hiren N Doshi: We cater to all neonates that are born at our institute, plus we get transfers from many smaller maternity homes all around the city. We have treated neonates beginning from 24 weeks of gestation. We see a large number of neonates with hypoxic-ischemic encephalopathy, along with meconium aspiration syndromes. We have a well established pediatric cardiology team and deal with many interventional and surgical cardiology patients. We also see neonates with septic shock and multi-organ failure on a regular basis. We have our share of surgical cases and genetic and metabolic disorders as in any tertiary level care NICU.

Which types of non-invasive solutions do you commonly use with neonatal patients?

Dr Suresh Birajdar: We have two dedicated locally manufactured Bubble-CPAP units, which we use in our neonates, either primarily or as a step down from mechanical ventilation. We have used nasal prongs as the most common interface in neonates. Even though we did try nasopharyngeal tubes, and masks, we were not very comfortable with them, probably because of the unavailability of proper interfaces at our center.

When treating pre-term infants with invasive ventilation modes, which modes or methods do you frequently prefer?

Dr Doshi: During the last four years I have been ventilating babies mainly on SERVO Ventilator 300, and most recently on SERVO-i. Since the shift over to the SERVO platform, we have used Pressure Regulated Volume Control - PRVC in almost all our cases. We prefer using PRVC as it has decreased the monitoring required in ventilating the baby. The ventilator adjusts itself to the changing lung compliance. This has tremendous advantages over the traditional pressure mode ventilation because the chance of accidentally causing an air leak, when the lung compliance improves is a thing of the past. Hypoventilation in a situation of worsening lung condition does not happen. In a teaching facility like ours, where the medical and nursing staff is constantly being rotated, there is always a learning curve with a fresh inflow of personnel, PRVC mode has obvious advantages. Also with the SIMV-PRVC mode now available on the SERVO-i, even weaning babies on the same mode is possible.

When we have a shortage of ventilators in our unit, we still use the SERVO Ventilator 900 (from our adult ICU) in the PC mode or the SIMV with PS mode. In my opinion, volume mode ventilation has a large advantage over pressure mode ventilation, and I have always been a proponent for volume modes, but I also feel that any mode of ventilation that the medical team is comfortable with, can be used to ventilate both neonates and children.

Is surfactant therapy used regularly?

Dr Doshi: We have used surfactant in around 150 neonates in the last 3 years for IRDS, in 4 cases for meconium
What in your opinion are the biggest challenges in regard to mechanical ventilation therapy in neonates?

Dr Doshi: I think the biggest challenge in using ventilation therapy is to remove the fear of ventilators from the physician’s mind. My endeavour is to make ventilation therapy as simple and hassle free as possible, so that all pediatricians are able to use it for the benefit of their patients and it moves out of the realm of only intensivists, neonatologists and pulmonologists. To a large extent, I think it is our community itself, which has formed this aura around ventilation therapy that causes many to remain in awe of it, and not utilize this life saving therapy to the fullest.

I feel that educating healthcare providers in the basic principles of ventilation, namely:

- aspiration syndrome, and in 3 cases for ventilator induced lung injury/ARDS.
- We go mainly on clinical (respiratory distress and oxygen requirement) and radiological criteria for determining need for surfactant. Once it is decided to give surfactant, we use our own protocol to give it using a special ET tube with a side channel to avoid disconnection from the ventilator while delivering it. We generally use PEEP of 8 – 12 cm H₂O in PRVC mode to keep the lung open during the time of delivery. We give the surfactant in 6 different positions, as opposed to the standard two positions. This helps in better distribution of the surfactant and at the same time avoids periods of hypoxia or increased airway pressure because of the use of smaller aliquots of the surfactant. Secondly, we repeat doses of surfactant every 6 to 12 hours if the FiO₂ requirement is above 0.3, or if the PEEP requirement is above 3 cm H₂O. The main aim of repeated doses is to get the child off the ventilator within 24-48 hours of life. I strongly feel that exposing the premature lung to artificial ventilation beyond 48 hours negates the very purpose of surfactant therapy.

In recent times, in cases of mild RDS, we have been giving the surfactant, and then shifting immediately to bubble CPAP with nasal prongs instead of keeping the child on the ventilator. This approach works beautifully and the incidence of ventilator associated pneumonia -VAP, sepsis and bronchopulmonary dysplasia has come down significantly. Interestingly, we have seen 5 cases of “near term” above 2.5 kg babies with hyaline membrane disease in the last 2 years born of non-diabetic mothers. Even though this phenomenon is a described entity, it is supposed to be quite rare.
1) gentle ventilation (preventing VILI - ventilator induced lung injury),
2) asepsis, 3) importance of chest physiotherapy, 4) accepting lower saturations and higher PCO₂'s, 5) preventing ventilator-patient asynchrony and 6) open lung ventilation concept (optimum PEEP and lower tidal volumes) is much more important than bombarding them with information and arguments on the benefit of one mode over the other and attempts to get that perfect Pressure-Volume curve on the screen. No other ventilation platform gives us as simple an interface as the SERVO-i does.

What is the range of age for the different pediatric patients treated here?

Dr Birajdar: We treat children right from the neonatal age to the age of 18 years.

Can you describe some of the challenges in mechanical ventilation of pediatric patients, in terms of anatomy and physiology?

Dr Doshi: Every case that we see is different. The challenge is in correctly analysing the case and choosing the best mode of ventilation and initial settings for that particular child. As mentioned earlier, I am more interested in demystifying ventilation; rather than talking about complex ventilation strategies. Today, I want to use this platform to convey the message that if basic principles are followed, every healthcare provider can use ventilation therapy to the advantage of his or her patient.

For most cases with respiratory failure, (other than hyper-reactive airway disease, obstructive airway disease and in patients with raised intra-cranial pressure), our principles for ventilation are outlined in brief:

1) Gentle ventilation: Ventilation, by itself should not be an instrument for causing damage to the alveolar unit.
Practically this translates to using RSI (rapid sequence intubation) protocol while intubating, using FiO2 of less than 0.6 as soon as possible, using higher PEEP’s to prevent repeated opening and closing of alveoli, thus avoiding shear injury (open lung ventilation). Use tidal volumes of 6-7 ml / kg or less (or use the minimum possible PIP to attain the above volumes on Pressure mode ventilation)

2) Flexibility in choice of modes: Use whatever mode of ventilation your team is comfortable with, keeping in mind the above principles.

3) Higher Respiratory rates: Use higher rates to achieve an increase in minute volume, if required.

4) Never chase blood gases: Accept oxygen saturations of around 90%. Accept PCO2 in the range of 40’s and 50’s initially. If the child’s hemodynamics permit, and if there are no contraindications, even higher levels of PCO2 can be accepted by further decreasing tidal volume, thus being even more lung protective. The key to this is to allow a step-wise rise in PCO2’s every 12 hours so that the patient acclimatizes to each consequent higher level of carbon dioxide without exhibiting severe tachycardia and hypertension.

5) Lung toileting: Chest physiotherapy and proper suctioning technique of the airway every 3 to 4 hours is an important cornerstone in ventilation therapy and should never be neglected.

6) Prevention is better than cure: Preventing infections and ventilatory associated pneumonias is also a part of ventilation protocol and strict policy measures like hand washing augmented with chemical rubs and sterile gloving, care of long lines, etc should naturally be part of a PICU’s culture.

Having mentioned our ventilation protocol, I would now like to share a few points that I feel strongly about. Ventilation is not a means to an end, rather it is like a transitional support until the time the basic disease process is treated or corrected. Thus, devoting more time to treat the primary disease is very important. Ventilation-patient synchrony makes life much simpler for everybody.

We still use sedation and paralysis in many cases that we ventilate, except for the two extremes of age, preterms and teens, where we are comfortable to ventilate without their use. Having said that, we also come across children who are quite comfortable being on the ventilator and with them, we are not averse to conscious ventilation.

In many children in whom we use sedation and paralysis, as a policy, we monitor Bi-spectral levels and/or continuous EEG to assess the depth of sedation and pick up seizure activity. Special care is given to chest toileting and frequent changes in positions to prevent atelectasis. We also feel that this method of ventilation has major benefits; we have practically not seen air leaks since using this protocol. Accidental extubations, a bane of any intensive care unit, and the associated complications, are also virtually unknown in our patients.

Stress related hyperglycemia and other stress related complications that have been documented by many researchers are rarely seen in our children.

We have heard that you frequently use PRVC mode in pediatric patients. What is the basis of this preference? Is it due to the delivery of preset tidal volume with the lowest possible pressure, or the opportunity of sensing small deviations in pressure? Are there other advantages of PRVC in pediatric patients that you have experienced?

Dr Doshi: Let me give you a case illustration as a practical example: I have a 2 kg preterm neonate with IRDS and have started him on VC ventilation, TV 15 ml; rr of 40, I: E of 1:2, PEEP of 8 cm H2O and FiO2 of 0.6. The peak pressure, measured is 30 cm H2O. Now, we shift the baby to PRVC mode, keeping all the above settings static, and adjusting the upper pressure limit to 45 cm H2O; after a few breaths the baby’s peak pressure stabilizes to a level of 27 cm H2O (3 cm less than VC mode), this is the magic of the decelerative flow pattern that PRVC uses.

Now, we give the baby a dose of surfactant. After delivery, we decrease the PEEP to 6 cm H2O and the attending nurse is trained to titrate FiO2 downwards...
to keep the SPO₂ 95%. After 2 hours, the peak pressures are at 20 cm H₂O, without us adjusting any setting on the ventilator. We decrease the PEEP to 4 cm, and after 2 more hours the peak pressures have reached 16 cm H₂O and the nurse informs us that the FiO₂ requirement is 0.3. This is the beauty of PRVC mode, the child has practically weaned off the ventilator by himself without much intervention from our side. We check that the respiratory drive is good, and if there are no contraindications to extubation, we extubate the child and shift to nasal CPAP as a step down.

The technology behind this entire process, I know is phenomenal and extremely complex, but for me, the end user, things have been made so simple. I can now rely on my junior-most team member to manage the ventilated patients on PRVC easily. With years of working with the SERVO ventilator platform, I have now reached the level of confidence in the systems, such that ventilation has become predictable and rote to perform in our unit.

This confidence also stems from the fact that the SERVO ventilator platform has the most sensitive trigger system as compared to other machines, and I have tried them all, even without the use of Y-sensor. Also the enormous sensing rates are unbelievable, the advantage is very clear at the bedside when we use the machines, and cannot be adequately described in words.

In your opinion, what are the most important parameters to look for in ventilatory performance to meet the specific needs of children?

Dr Birajdar: An uncluttered simple interface coupled with precise delivery of smaller volumes per breath and the ability to minutely sense the child’s efforts are the absolute requirements in any ventilator for pediatric and neonatal use. In addition, choice of modes, including non-invasive modes, and ones like ventilation graphics, ability to use the same machine in all patient groups, inbuilt ultrasonic nebulisation device, robust all-climate build, alarm memory, sensible algorithms for back-up ventilation, etc.

What in your opinion are the most important developments in ventilation therapy or procedures for neonatal and pediatric patients respectively, which have occurred in the last decade?

Dr Doshi: A paradigm shift in ventilation strategies and understanding the physiology of VILI are the two most important developments in the last
Regarding training for the newer SERVO-i’s, it was a natural transition and was quite hassle free as everybody used to working on the SERVO platform using the 300’s and every team member had ample experience on using PRVC modes of ventilation.

Could you give us some general information regarding patient demographics?

Dr Birajdar: We had 360 neonates admitted to our NICU in 2006, and had an overall mortality of 3.6%, we were required to ventilate 170 amongst them due to a variety of reasons and had a mortality rate of 6.5% amongst this group. We had 401 pediatric admissions in 2006, to our PICU, and had a mortality rate of 3.24%

Our NICU (tertiary level care) has 3 beds, premature unit (secondary level care) has 8 beds and PICU (tertiary level) has 5 beds. Our pediatric ward has 16 beds, with an option to admit 6 to 7 more children in other parts of the hospital. Our pediatric general ward (free beds) has 12 beds.

The hospital has 450 beds and always runs with an average 90 to 95% occupancy.

Admission and ventilation statistics for 2006

<table>
<thead>
<tr>
<th>Month</th>
<th>NICU</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Ventilated</td>
<td>Not Vent.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan</td>
<td>25</td>
<td>15 / 1</td>
<td>10 / 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb</td>
<td>35</td>
<td>12 / 1</td>
<td>23 / 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar</td>
<td>25</td>
<td>13 / 0</td>
<td>12 / 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr</td>
<td>25</td>
<td>9 / 0</td>
<td>16 / 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>28</td>
<td>14 / 1</td>
<td>14 / 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun</td>
<td>30</td>
<td>16 / 1</td>
<td>14 / 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jul</td>
<td>27</td>
<td>11 / 1</td>
<td>16 / 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug</td>
<td>32</td>
<td>18 / 1</td>
<td>14 / 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sep</td>
<td>39</td>
<td>20 / 2</td>
<td>19 / 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct</td>
<td>38</td>
<td>12 / 0</td>
<td>26 / 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov</td>
<td>28</td>
<td>16 / 1</td>
<td>12 / 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec</td>
<td>28</td>
<td>14 / 1</td>
<td>14 / 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>360</td>
<td>170 / 11</td>
<td>190 / 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Month</th>
<th>PICU</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cardi</td>
<td>Neuro</td>
<td>Surgi. &amp; Trau.</td>
<td>Infec. &amp; Ot</td>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan</td>
<td>8 / 0</td>
<td>5 / 0</td>
<td>4 / 0</td>
<td>22 / 0</td>
<td>39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb</td>
<td>6 / 1</td>
<td>8 / 0</td>
<td>3 / 0</td>
<td>12 / 0</td>
<td>29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar</td>
<td>2 / 0</td>
<td>7 / 0</td>
<td>5 / 1</td>
<td>12 / 0</td>
<td>26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr</td>
<td>5 / 1</td>
<td>6 / 1</td>
<td>2 / 0</td>
<td>14 / 1</td>
<td>27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>7 / 0</td>
<td>6 / 1</td>
<td>4 / 0</td>
<td>10 / 0</td>
<td>27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun</td>
<td>7 / 1</td>
<td>10 / 0</td>
<td>4 / 0</td>
<td>14 / 0</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jul</td>
<td>5 / 0</td>
<td>2 / 0</td>
<td>6 / 0</td>
<td>12 / 1</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug</td>
<td>2 / 0</td>
<td>8 / 0</td>
<td>4 / 1</td>
<td>18 / 1</td>
<td>32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sep</td>
<td>4 / 0</td>
<td>8 / 0</td>
<td>6 / 1</td>
<td>22 / 0</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct</td>
<td>10 / 0</td>
<td>10 / 1</td>
<td>9 / 0</td>
<td>12 / 0</td>
<td>41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov</td>
<td>11 / 1</td>
<td>12 / 0</td>
<td>3 / 0</td>
<td>15 / 0</td>
<td>41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec</td>
<td>8 / 0</td>
<td>9 / 0</td>
<td>7 / 0</td>
<td>15 / 0</td>
<td>39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>75 / 4</td>
<td>91 / 3</td>
<td>57 / 3</td>
<td>178 / 3</td>
<td>401</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Have there been any specific advantages in terms of education and training in regard to the new SERVO-i ventilator fleet?

I do not have any personal experience in using Neurally Adjusted Ventilatory Assist - NAVA, but from what I have read about it, I am eagerly waiting to try it out and incorporate it in our ventilation policies. Possibly, it is the answer to my doubts about the shortcomings of the present synchronous modes of ventilation.

decade. I salute those who have done so much research in this area and then proven their theories in clinical studies. They probably have indirectly saved millions of lives after their lung protective ventilation strategies were adopted by clinicians all over the world. The industry has also given great support to this endeavour in three different ways; one by technological advancement that has remained in step with newer strategies, and making the ventilator interface more simple. Secondly, they have shown great foresight by being an instrument to spread this knowledge widely all over the world by various means; journals and training programs. Lastly, the industry’s willingness to support purchase of ventilators in the developing and under-developed regions of the world has allowed us to remain in sync with the western world in terms of giving the benefits of newer technology to our patients.

Could you give us some general information regarding patient demographics?

Dr Doshi: I firmly believe that ventilation therapy can be taught only at the bedside. We have a system in place whereby we always have at least two senior and experienced faculty members in the unit at any given time. The learning process for juniors is a continuous process and involves discussion on daily rounds, hands-on working and observation. Before they are allowed to go near a ventilator, they are first trained in our infection control protocols. Once we feel that they have imbibed the importance of proper aseptic techniques, they are allowed to work bedside. They are then taught basic techniques of proper suctioning and chest toileting, and it forms the bulk of their duties in the PICU for the first 6 months. By this time they have started understanding the basics of ventilation, and start gaining confidence in decision making. They are being continuously assessed by us, and based on their abilities we allow them to take critical decisions in patient care, and shift our roles to mainly supervisory. This is a very rustic method of training, but works very well. All the graduates who have worked in our unit for a period of at least one year, are now spread all over the country and I am proud to say, manage their own small units and are confident to treat any challenge that comes their way, and reproduce the same fantastic outcomes that we do here. Our nursing staff are also trained in a similar fashion and are equally important members of the team.

I do not have any personal experience in using Neurally Adjusted Ventilatory Assist - NAVA, but from what I have read about it, I am eagerly waiting to try it out and incorporate it in our ventilation policies.

Possibly, it is the answer to my doubts about the shortcomings of the present synchronous modes of ventilation.

I do not have any personal experience in using Neurally Adjusted Ventilatory Assist - NAVA, but from what I have read about it, I am eagerly waiting to try it out and incorporate it in our ventilation policies.

Biography

Dr Hiren N Doshi has over 11 year’s expertise in pediatrics, neonatology, pediatric critical care and pediatric cardiac intensive care. He obtained his initial medical degree at the Krishna Institute of Medical Sciences at Shivaji University in 1994, and had his speciality training at Dr Balabhai Nanavati Hospital in Mumbai in 1998, and is board certified from the national board of examinations, New Delhi. Dr Doshi has conducted research in the areas of microbiology of otitis media in children as well as endocrine complications in thalassemia major with emphasis on diabetes mellitus. His current research plans are within the area of newer modalities and refinements in ventilation in neonates and children, and decreasing morbidity and mortality in extreme low birth weight babies. He has organised workshops in India within the area of pediatric critical care and pediatric cardiac intensive care. Dr Hiren Doshi presently works as Senior Intensivist and Pediatric and Neonatal Consultant at Dr Balabhai Nanavati Hospital in Mumbai, and has held this position for the past three years.

Dr Suresh Babruvhan Birajdar received his initial medical training at Bharti Vidyapeeth’s Medical College at the University of Pune, India. He obtained his degree in pediatric at the Seth G S Medical College and King Edward Memorial Hospital in Mumbai in 2005, and thereafter worked as registrar in the Neonatal Intensive Care Unit at King Edward Memorial.

Dr Birajdar has participated in numerous pediatric and neonatal workshops and conferences, and received first prize for Oral Award Paper entitled “Psychological Consequences in Pediatric Intensive Care Survivors: The Unsuspected Impact” at the First Asia Pacific Congress on Pediatric Critical Care in 2005. Dr Birajdar is currently employed as a Pediatric Intensivist at Dr Balabhai Nanavati Hospital in Mumbai.

References


