American Association for Respiratory Care's
Neonatal Pediatrics
January / February 2003 Bulletin

Notes from the Co-Editor

by Melissa K. Brown, RCP, RRT-NPS

I am happy to mark this first Bulletin of 2003 by proudly displaying our new NPS (Neonatal Pediatric Specialist) credential behind my byline. I know many of you have waited a long time to be awarded a credential that recognizes your expertise in this specialty. Congratulations to all who have earned it!

In this edition, of the newsletter we wrap up Alan Roth's series on "Ethical Issues Concerning Low Birth Weight or Handicapped Infants." Thanks, Alan, for sharing your wealth of experience and for your multiple contributions to our section!

Also in this edition, Michael Tracy, RRT, provides us with an excellent comprehensive review of the studies looking at nasal cannula and their delivered FiO_2 in the NICU. I find this to be an extremely interesting area of study that has much clinical significance. Many times my colleagues and I have debated these issues at the bedside. How much oxygen is the baby really getting? Is he getting any oxygen? Are we just obstructing his airway with the nasal cannula at such low flow? How should we wean? And the big one: Are we prolonging the length of time the patient is spending on oxygen with the weaning method we are using?

I have often seen room-air nasal cannulae used in the NICU. The physician's justification has always been that the flow of the cannula provides stimulus or CPAP. According to the work by Vain, the infant is breathing sub-ambient oxygen percentages. Is this clinically significant? Are room air cannulae useful? Sreenan's work looking at nasal cannulae as CPAP devices has been discussed at length in the Bulletin before, but I would again

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Ethical Issues Concerning Low Birth Weight or Handicapped Infants: Part Three

by Alan Roth, MS, MBA, RRT, FAARC, director of clinical operations; clinical instructor, school of medicine, department of anesthesiology, Mount Sinai Medical Center, New York, NY

Editor's Note: In our last issue, Alan Roth explored some of the ethical principles for continuing or discontinuing treatment in cases involving severely handicapped newborns. In the final article in his three-part series, he presents some factors to consider when making decisions regarding these children.

The establishment of infant bioethics committees consisting of both physicians and non-physicians can provide consultation and review on cases involving low birth weight or handicapped infants, ensuring that sensitive treatment decisions are made in a reasonable, informed, and caring manner. These committees provide an educational resource for hospital personnel and for families, and establish specific policies and guidelines for practitioners dealing with the issue of life-sustaining treatment. But as the case presented in the first article in this series showed, they often fail to elicit a consensus on what's best for the child. What, then, can we do to resolve these often heartbreaking situations?

An ethical dilemma

The ethical dilemma is not whether to provide care in the ICU unit but to justify not providing it. Survival does not take into account the iatrogenic problems or sequelae to procedures to prolong life (particularly in the area of intraventricular hemorrhage). If intensive care is withdrawn, the intention is that the baby should die. This moral issue is relevant to both the congenital malformed child with multiple defects and the extremely low birth weight infant. The quality of life issue and the balance between parental decision-making and the interests of the infant clearly call for responsible actions. We cannot take the view that preservation of individual human life is an end in itself, irrespective of the social, economic, or personal cost. Life does have value, but it is not sacred in the extreme.

Selective non-treatment of severely handicapped infants has become more difficult as outside influences and lawgivers have interfered with the physician-parent relationship. Quality of life issues are ill defined and colored by many biases, because treatment issues cannot always produce the desired outcome. Immature systems may react to the iatrogenic intrusions in ways we cannot foresee, or the sequelae may lead us down an unintended path.

Normalcy—or lack thereof—should not be the bellwether for treatment decisions. Rather, when considering withdrawing support, there should be a reasonable expectation that the infant would lack the capacity to lead a recognizable human life. In reality, this would include infants who have no response or only primitive reflexive response to stimulation (infants who lie virtually motionless in their beds, essentially unaware of the world around them).

The question arises as to whether there is ever a justification for not treating handicapped infants who have the potential to minimally engage their physical environment (sitting up, reacting to sounds). But in these circumstances, medically indicated treatment still may not serve the interests of the infant. However, to reach this conclusion, it must be clear that the pain and suffering associated with the proposed life-sustaining treatment would be wholly disproportionate to the infant's potential for achieving any personal satisfaction or human interaction. The benchmark here is the clear diagnosis of death even if it is not in the immediate newborn period.

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Correction: In the last issue of the Bulletin, Wade Rich's article, "Controlled Ventilation in the Delivery Room: What's Old is New Again," should have included a pressure waveform graphic for both the Neopuff and the anesthesia bag. Due to a mix-up in the layout process, only one graph appeared in the article. We apologize for the error, and want to let you know Wade's article appears in corrected form in the online version of the Bulletin on the Neontal-Pediatric Section homepage on http://www.aarc.org/sections/peri-pedi_section/peri-pedi.asp.

Oxygen Delivery in Infants: Nasal Cannulae, Flow, and Delivered F_{IO_2}

by Michael Tracy, RRT

In 1989, Vain et al[1] published the first article dealing with oxygen delivery via nasal cannula while measuring the F_{IO_2} delivered to the hypopharynx (F_{hO_2}). F_{hO_2} was measured with flow of 0.25, 0.50, 0.75, and 1.0 L/m. Each flow was tested with F_{IO_2}s of 0.40, 0.60, 0.80, and 1.0.

Measured F_{hO_2}s were significantly different for each blender setting and flow rate. In addition, infants tested while breathing room air at 0.25 to 1.0 L/m were found to have F_{hO_2}s of 0.16 to 0.18, indicating mixing of inspired and expired gases. F_{hO_2} dropped 17.7 (5.4 when the infants were crying. Vain et al also referred to Schacter's[2] work in adults, which revealed F_{hO_2} decreases at higher respiratory rates and during mouth breathing.

Vain et al proposed the following predetermined "practical guideline for weaning":

1. Start with F_{IO_2} = 1.00 and incrementally decrease flow from 1.0 L/m to 0.25 L/m
2. Increase flow to 0.75 L/m at F_{IO_2} = 0.80 and wean flow back to 0.25 L/m
3. Repeat step 2 with F_{IO_2} = 0.60
4. Wean flow only

Based on their data, Vain et al did not see a need to wean F_{IO_2} <0.60 when using a blender. Benaron et al[3] criticized this approach, commenting; "Certain combinations of flow and oxygen may be inherently more stable than others." The study objective of Benaron et al was to "assess the impact of different weaning strategies on the stability of inspired oxygen concentrations and identify optimum strategies to maximize stability." They performed a theoretical analysis and compared their results to Vain's and Schacter's data, deriving a predicted delivered F_{IO_2} that incorporated adjustments in flow, oxygen concentration, T_i, V_t, and the fraction of nasal breathing (F_{ncO_2}). The results state an increase in F_{IO_2} in the nasal cannula proportionally increases the delivered F_{IO_2} until the cannula flow exceeds the nasal flow.

The derived equations are:

$$F_{IO_2} = F_{atmO_2} + \left(\frac{Ti + Vnc}{Vt}\right) \times (F_{ncO_2} - F_{atmO_2}) \text{ if } Vnose \geq Vnc$$

OR

$$F_{IO_2} = F_{atmO_2} + f_{nose} \times (F_{ncO_2} - F_{atmO_2}) \text{ if } V_{nose} < V_{nc}$$

(The equations assume the upper airway does not act as a reservoir, 67% nasal breathing, 5 mL/Kg V_t, I:E = 1:1, and RR = 65.)

Benaron et al found their derived values overestimated the delivered F_{IO_2} by approximately 4% when compared to the measured results of Vain and Schacter. Benaron et al made the following recommendations for infants with immature retinas.

To begin cannula supplemenlation:

1. Use only undiluted 1.00 oxygen.
2. Adjust flow rate using microcalibrated flowmeter.
3. Use minimum flow sufficient to achieve oxygenation goals.

To wean supplementation:

1. Wean flow in 0.05 to 0.10 L/m steps as tolerated until minimum flow (0.05 to 0.10 L/m) is reached.
2. Once at minimum flow, wean oxygen concentration in steps by 10-20%.
3. Discontinue oxygen once at minimum flow and concentration (21-50%) as tolerated.

To increase supplementation:

1. If oxygen is diluted, increase oxygen concentration in steps up to 100% before increasing flow.
2. Increase flow incrementally by steps of 0.10 to 0.25 L/m.
3. If high flows (>1 to 2 L/m) and 100% oxygen is required, consider mask, hood, CPAP, or intubation as appropriate.

Benaron concluded that this avoids large changes in supplemental oxygen delivery and allows for a lower minimum flow rate and simpler comparison between oxygen requirements over time. Benaron's take on the Vain guidelines is that "it is hard to know if there is clinical improvement, masking a deterioration, or representing no real change at all."

In 1996 the STOP-ROP investigators[4] used the Benaron equations and assumed the following additions: T_i = 0.3 sec, V_t = 5 mL/Kg, and that either inspiration is entirely nasal or that the cannula flow is sufficiently low that the infant exhales all output from the cannula. The investigators created "conversion tables" for infants on nasal cannulae. The first created a "factor" as a function of flow and weight. The second calculated the effective FIO_2 as a function of "factor" and oxygen concentration. These tables eliminate the need to continually mathematically recalculate the FIO_2 and are clinically easier and simpler to apply.

In 1996, Finer[5] et al[5] measured the actual FIO_2 delivered to neonates using a low-flow flowmeter and derived another formula to determine the delivered FiO2.

$$FIO_2 - \frac{O_2 \text{ flow (mL x 0.79)} + (0.21 \times V_e)}{V_e} \times 100$$

Their study showed good correlation between the predicted FIO_2 and the measured pharyngeal FIO_2. They studied infants ranging in weight from 590g to 4020g. For infants less than 1500g, actual FIO_2 varied from 25-95%, with a 7-10% increment in FIO_2 for every 25 mL increase in flow. For infants from 1500-2000g, the highest available FIO_2 was approximately 70%, with a mean FIO_2 of 47% at 200 mL/m flow. The highest achievable FIO_2 ranged from 47% in infants >2000g down to 29% in a 4100g infant. Finer stated that the limitation of the low-flow flowmeter is its inability to deliver >50% FIO_2 to infants >2Kg. To date no data have been published using all three methods of nasal cannula oxygen delivery techniques and showing effects of each method on a single patient.

In 2001, Sreenan et al[6] used a high-flow nasal cannula to manage apnea of prematurity. An esophageal balloon was placed to measure the positive distending pressure created by nasal CPAP + 6.

Following measurement of distending pressure, the patient was changed to a nasal cannula. Flow was increased until the distending pressure was equal to that provided by the CPAP + 6. Each patient was followed for six hours while on both nasal cannula and CPAP. (Entry criteria for the study required successful completion of 24 hours on CPAP prior to enrolling in the study.)

This study demonstrated that nasal cannula at flows up to 2.5 L/m can deliver positive distending pressure in neonates up to 2 Kg and are as effective as nasal CPAP in the management of apnea of prematurity. The investigators found no significant differences in the frequency or duration of apneas, bradycardias, or desaturations among the two groups. There was no need to increase the FIO_2. Sreenan states that there was no mucosal drying or trauma to the nares. Finer makes the same claim for the low-flow oxygen delivery.

Nasal cannula use in the NICU environment runs from low flow to high flow, blended to unblended, in the treatment of hypoxia and apnea of prematurity. Benaron and the STOP-ROP tables show that even on supplemental oxygen, the effective FIO_2 can be 21%. Sreenan's work shows that even with FIO_2 = 21%, flow/positive distending pressure (PDP) can be an effective tool. Finer points out that continuous monitoring continues to be the most effective way to determine whether the infant is receiving an appropriate inspired oxygen concentration. The best monitoring devices still require appropriate responses to alarms to maintain appropriate saturations that are necessary for each individual patient requirement.

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like to strongly caution that his study was small and of a short duration, and he did not describe which size cannulae were used. The devil is in the details, as they say. Sreenan did not prove anything. More studies would be of interest.

In my experience some of the worst side of effects of weaning both nasal cannulae flow and FIO_2 are staff confusion, inconsistent delivery of oxygen, and prolonged weaning. Vain's complex method of weaning described in this issue would have caused complete chaos for the NICUs I have worked in. However, I do agree with the recommendation not to wean the blender FIO_2 below 60% when on 250 cc or less, and to wean flow only at that point. I think this method provides better information about the weaning status of the patient and avoids inadvertently leaving a baby on supplemental oxygen who doesn't need it due to a combination of low flow and low FIO_2.

I believe the most important change we are making today in the NICU is the lowering of acceptable oxygen saturation levels and improved monitoring of these levels, as well as managing our response to alarms. It would be most helpful, however, to have evidence-based weaning guidelines in place that all staff can easily understand and utilize and that don't leave neonates on nasal cannulae that are no longer of clinical benefit. Thanks, Michael, for a very thought-provoking article!

Now, how are all of you weaning from nasal cannulae in your NICU? ◆

In Brief . . .

Section Chair Tim Myers reminds section members that:

- The NBRC will be offering credentials in 2003 for past and present completion of the Neonatal-Pediatric Specialty Examination.
- RESPIRATORY CARE plans to publish Journal Conference proceedings specific to neonatal/pediatric respiratory care in its March and April editions.
- Section members will elect a new chair this Fall. We will need to identify candidates for the Election Ballot by Summer. ◆

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ETHICAL ISSUES CONCERNING LOW BIRTH WEIGHT OR HANDICAPPED INFANTS: PART THREE

Other important characteristics include:

- Severe or progressively increasing pain and suffering.
- Severely impaired cognitive and learning potential that precludes social or human interaction.
- Multiple physical disabilities preventing any significant voluntary movement.
- Multiple severe impairments or absence of sense perception, particularly sight and hearing.

A balancing process, conducted on a case-by-case basis, should determine whether an infant falls into the non-treatment category. Clear medical evidence indicating that the infant is afflicted with most or all of the cluster items would warrant a non-treatment decision. Inconclusive or contradictory medical evidence would favor administration of feasible treatment. Any neonate, who with treatment can expect to live and progress through infancy to childhood and who is capable of human feeling and social response, should be sustained by efficacious medical treatment.

Guidelines do not consider the withholding of medically indicated treatment to be medical neglect if: (1) the child is chronically and irreversibly comatose, (2) treatment would merely prolong dying, (3) treatment would not be effective in ameliorating or correcting all of the infant's life-threatening conditions, or (4) treatment would otherwise be futile in terms of survival of the infant, and (5) the treatment itself, under the circumstances, would be inhumane. However, even if the infant meets these criteria, he must still receive appropriate nutrition, hydration, and/or medication.

No clear answers

The birth of an infant with a major malformation or critical illness often presents parents and physicians with an agonizing dilemma. The normal instinct to care for and treat the infant may be overwhelmed by fears of the harm such treatment may cause, either for the infant or family. To avoid such suffering, physicians may consider or parents may request withholding or withdrawing life-sustaining treatment. In some cases, death is imminent regardless of treatment. In others, like anencephaly, the child may be so impaired that treatment will serve only to maintain biologic functions. Conversely, some patients have malformations consistent with long and often enjoyable lives (such as Down's syndrome), yet their parents still request withholding or withdrawing life-sustaining treatment.

For others still, the future is more difficult to predict - they are surely awaiting an imminent and unavoidable death, but it is unclear what measures should be used to maintain comfort during the dying process. Disagreement about the proper course of action in these cases is common. It is impossible to identify a consensus on which infants or children within this broad range should be treated. Insisting that all infants be treated does not serve the interests of patients who are so impaired that there is no likelihood of them benefiting from treatment or those for whom treatment will bring more pain and suffering without compensating benefit. The range of complexity in these situations makes it impossible to define clinical criteria for withholding treatment. ◆