

Conference summary: a celebration of a century of neonatal care

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In conjunction with the centennial celebration at Baylor University Medical Center in October 2003, the Department of Pediatrics at Baylor sponsored a daylong symposium in neonatology for physicians, nurses, and other health professionals. Attendees filled the auditorium almost to capacity as speakers from Baylor and around the nation shared a variety of perspectives on the past, present, and future of this rapidly changing specialty. The sessions are summarized below.

HISTORY OF NEONATAL CARE IN NORTH AMERICA

M. Terese Verklan, PhD, CCNS, RNC

University of Texas Health Science Center, Houston, Texas

In the 1920s, more than half of all births in large cities took place in hospitals, prompting the establishment of newborn nurseries and stimulating an interest in the medical care of the newborn. By the 1950s, a few pediatricians were beginning to create the specialty of neonatology. Dr. Verklan reviewed several important developments in the field:

- *The Apgar score.* In the early 1950s, Virginia Apgar proposed a standardized assessment at birth. The Apgar score remains a valuable predictor of babies who will need ongoing support and those at higher risk of mortality.
- *Thermoregulation.* The inability of preterm infants to keep themselves warm was recognized in the late 19th century and was the rationale for the development of incubators. The consequences of thermal imbalance include increased metabolic rate and oxygen consumption, hypothermia/hyperthermia, and hypoglycemia. The effects of humidity and noise levels associated with incubators are topics currently under study.
- *Nutrition.* The development of formula in the early to mid 1900s provided new options for infant nutrition but also prompted new questions. Breastmilk is ideal for term infants, but what about preterm infants? Nutrition in the neonate is the focus of ongoing research and clinical discussion.
- *Perinatal hypoxic-ischemic brain injury.* Specific vulnerabilities distinguish the immature brain from the term brain, and the potential mechanisms of injury are diverse. Recent studies have identified an important association between chorioamnionitis and brain injury. Resuscitation with room air has been shown to be as effective as traditional resuscitation with 100% oxygen, indicating that a reevaluation of current treatment guidelines may be needed.
- *Respiratory distress syndrome.* In 1959, surfactant deficiency was identified in the lungs of infants dying of hyaline membrane disease. Surfactant replacement therapy is now routine but cannot correct the abnormalities in very low birth weight infants with respiratory distress syndrome or those with certain coexistent morbidities. Questions remain regarding optimal dose, optimal number of treatments, and most effective formulation of surfactant.
- *Artificial ventilation.* Early developments in artificial ventilation took place in the 1960s and 1970s. Alternatives to conventional ventilation include patient-triggered ventilation, high-frequency ventilation, and high-frequency oscillatory ventilation (HFOV). Related advances that are in use or under study include inhaled nitric oxide, extracorporeal membrane oxygenation, and partial liquid ventilation using perfluorocarbon liquids.
- *Monitoring.* The development of microprocessors and microtransducers has resulted in exponential growth in the number and types of monitoring devices.
- *Regionalization of care.* Improved outcomes are coincident with regionalized perinatal care, outreach education for nurses and physicians, transport systems for mothers and newborns, and increased public awareness that high-risk pregnancy outcome can be improved with modern perinatal medicine techniques.
- *Neonatal surgery.* Advances in neonatal surgery are closely linked to advances in pediatric anesthesiology and required the development of miniaturized equipment. Other important developments in the field are total parenteral nutrition and an improved understanding of neonatal physiology.
- *Nursing.* Neonatal nursing has evolved as a subspecialty of maternal-child nursing and includes nurse practitioners, clinical nurse specialists, and critical care nurses. These professionals are a vital part of the neonatal care team.

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HIGH-FREQUENCY OSCILLATORY VENTILATION: STRATEGIES FOR CLINICAL MANAGEMENT

Donald M. Null, Jr., MD

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High-frequency ventilation, defined by the US Food and Drug Administration as >150 breaths per minute in the neonate and >60 breaths per minute in the adult, delivers small tidal volumes at high rates. Several types of high-frequency ventilators are in use; Dr. Null focused on HFOV in the neonate. Unlike airflow in conventional ventilation, an oscillatory waveform put through an endotracheal tube is dramatically dampened.

Because regional differences in the lung can vary according to the disease being treated, a thorough understanding of the patient's pathophysiology is essential in setting up and adjusting the ventilator. When used appropriately, HFOV can reduce pressure transmission and barotrauma because volume delivery to the distal lung is much smaller than that with conventional ventilation.

Dr. Null cited several clinical studies comparing HFOV with other ventilation methods in preterm and very low birth weight infants. He also noted the difficulties involved in clinical research owing to the lack of standardization in this area: ventilatory care varies not only among centers but also among physicians within a center.

A variety of lung diseases can be treated successfully with HFOV. Dr. Null provided specific guidelines for clinical management of the following diseases in both premature and term/near-term infants:

- Diffuse alveolar disease
- Air leak
- Nonhomogeneous lung disease (meconium aspiration with air trapping; meconium aspiration, diffusely hazy; and focal pneumonia)
- Pulmonary hypoplasia

He concluded by providing basic concepts of weaning infants off of HFOV, noting that it is unnecessary to use conventional ventilation during this process. He stated that HFOV "makes a difference over the long haul."

FETAL SURGERY

Russell W. Jennings, MD

Harvard Medical School, Boston, Massachusetts

The fetus has always been mysterious and still is; it has completely different anatomy and physiology than the newborn. At the Advanced Fetal Care Center, associated with Children's Hospital of Boston, a multidisciplinary approach is used to provide the finest diagnosis and care for a mother carrying a fetus with an anomaly. By using advanced fetal imaging and diagnostics, the center focuses on complex cases and provides timely, coordinated care with referring and primary caretakers. Expert judgment is needed to keep the benefits and risks of treatment in realistic perspective and to ensure that the mother is not harmed.

Dr. Jennings discussed a variety of fetal anomalies that have been successfully treated at the center, including hypoplastic left heart syndrome, congenital cystic adenomatoid malformation, cervical teratoma, bronchogenic cyst, and congenital diaphragmatic hernia.

In high-risk fetuses with congenital diaphragmatic hernia or a large congenital cystic adenomatoid malformation, ex utero in-

trapartum treatment is used. In this intervention, partial delivery of the fetus enables the team to perform a variety of procedures (intubation, delivery of surfactant, and a trial of ventilation while monitoring oxygen saturation) while the placental circulation is still intact. If necessary, the fetus is placed on extracorporeal membrane oxygenation prior to delivery.

Evidence of the center's success was demonstrated by a graph that compared national mortality rates for congenital diaphragmatic hernia with rates from Children's Hospital of Boston. The most pronounced difference was seen in 2000 through 2002, after implementation of the center's current treatment strategy: the national mortality rate remained above 25% while the rate at Children's Hospital of Boston dropped below 10%.

ETHICAL DILEMMAS IN NEONATAL INTENSIVE CARE

Thomas W. Mayo, JD

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The original Hippocratic goals of medicine balanced two well-defined positions: curing disease when possible yet recognizing the limits of treatment and therefore acknowledging when death is inevitable. The modern revolution in medical technology, however, has changed when, where, and how we die and has created medical and even spiritual confusion about death. The landmark legal case in 1976 involving Karen Quinlan, a young woman in a persistent vegetative state, brought to the forefront these difficult questions: Who makes decisions for the incompetent patient, and what is the basis for decision making? The court established "substituted judgment," or an approximation of the patient's own wishes, as the standard for decision making by surrogates. Mr. Mayo explained that the same difficult questions pertain to the imperiled newborn; however, the standard of substituted judgment cannot be applied. Thus, court decisions in other cases, as well as state and federal laws, have shaped current treatment guidelines.

Rather than clarifying the standard of care, these rulings and regulations have often been contradictory and difficult to interpret. For example, Mr. Mayo cited an Indiana case in which the court sided with parents who rejected surgery for their infant with trisomy 21 despite the objections of the pediatrician and pediatric consultant. In response, the US Department of Health and Human Services promulgated the "Baby Doe rule" pursuant to the Rehabilitation Act of 1973. Based on federal law against discrimination, the rules stated that treatment, including life-saving and life-sustaining treatment, must be provided if the patient is "otherwise qualified" to receive the benefit in question. Signs posted in hospitals warned against "discriminatory failure to feed and care for handicapped infants," and a 1-800 hotline was set up for reporting violations. In 1986, however, the US Supreme Court invalidated the rule. Congress responded by categorizing as child abuse the "withholding of medically indicated treatment" from infants and then made prevention of child abuse a prerequisite for the receipt of federal funds by state child protective services programs. These regulations, sometimes called the "new Baby Doe rule," delineate only 5 exceptional circumstances when treatment is *not* medically indicated for an infant's life-threatening condition (e.g., the infant is "chronically and irreversibly comatose").

Where do we stand today? At the federal level, the new Baby Doe rule remains in place. At the state level, 2003 amendments to

the Texas Advance Directives Act added “dispute over treatment decisions for minors” to the list of disputes to which due-process safe harbor and resultant immunities apply. According to Mr. Mayo, this language opens the possibility for parents’ wishes to be overridden by physicians who can claim immunity. In addition, the possibility still exists that hospitals may be obligated by the new Baby Doe rule to resuscitate infants over the objections of parents. The debate over these complex and difficult ethical decisions continues.

EARLY AGGRESSIVE NUTRITION

Patti Thureen, MD

University of Colorado Health Sciences Center, Denver, Colorado

The argument for delivering early aggressive nutrition to the high-risk, very preterm newborn is based on the observation that nationally, we are producing postnatal growth retardation that is not reversed by the time of hospital discharge. High protein requirements, fluid losses, and energy expenditure combined with small energy reserves and poor gastrointestinal motility in these infants constitute a nutritional emergency. On the other hand, concerns about intolerance and toxicity (especially necrotizing enterocolitis) remain, and clear evidence about long-term benefit is lacking.

The standard of the American Academy of Pediatrics for postnatal nutrition in preterm infants is to duplicate normal in utero fetal growth rates, but no detailed guidelines for reaching this goal have been published. Dr. Thureen explained that normal fetal growth rate is difficult to achieve in extremely low birth weight infants and that weight gain alone does not guarantee “good growth.” She advocates the following steps in early aggressive nutritional support:

- Start total parenteral nutrition on the first day of life
- Give amino acids to prevent catabolism and in amounts that, hopefully, produce growth
- Advance glucose and lipids as rapidly as tolerated
- Give minimal enteral feedings (MEF) on days 1 and 2
- Aim for a “good” weight gain of 15 to 20 g/kg/day by days 10 to 12

Dr. Thureen stated that protein growth may be the best indicator of “real” growth, and evidence suggests that the amount of protein intake early in life correlates with developmental outcome. She and her colleagues compared the results of low and high intravenous amino acid intake in extremely low birth weight infants in the first 48 hours of life. Significantly greater rates of protein accretion occurred in neonates who received high amino acid intake (3 g/kg/day) compared with those who received the lower amount (1 g/kg/day); no evidence of toxicity was found (1).

Finally, Dr. Thureen discussed the role of MEF, also called “priming” or “trophic feedings,” in which formula or breast milk is given enterally in amounts from <1 to 25 mL/kg/day. There are no clear standards for MEF; however, Dr. Thureen advocates early trophic feedings followed by advancing nutritive feedings. The day of life to start enteral feedings, the volume of feeds, and the duration of both trophic and nutritive feeds depend on the infant’s clinical status and risk factors. Studies in extremely low birth weight infants and ill infants have demonstrated that MEF is safe and does not increase the incidence of necrotizing entero-

colitis. In addition, MEF provides psychological benefits, shortens the time to full feeds, and may shorten hospital stay.

BREASTFEEDING THE HIGH-RISK NEWBORN

Kathy Chaney, RN, IBCLC

Baylor University Medical Center, Dallas, Texas

The benefits of breastfeeding are many. In the infant, breastfeeding decreases the incidence of necrotizing enterocolitis and gastrointestinal and upper respiratory infections, reduces the severity of some allergic conditions, and decreases morbidity and the length of hospital stay for preterm and low birth weight babies. Breast milk confers host resistance factors and antiinfective properties, provides more easily digested and absorbed fat and amino acids, has a lower renal solute load, and includes specific growth factors that are important in the development and maturation of the brain, retina, and central nervous system.

In the mother, breastfeeding decreases postpartum bleeding and results in more rapid uterine involution; stimulates release of the hormone relaxin, which promotes nurturing and a sense of well-being; and induces lactational amenorrhea. Longer-term benefits include a reduced risk of ovarian cancer and premenopausal breast cancer and a lower incidence of long-bone and hip fractures. For the mother of an infant in the neonatal intensive care unit (NICU), providing breast milk takes on added significance: it is the one thing she alone can do for her baby when she may otherwise feel helpless.

Ms. Chaney explained that helping these mothers succeed at breastfeeding is an important goal of the NICU staff. Strategies include initiating breastfeeding early, encouraging the pumping of milk as soon as possible, promoting nonnutritive suckling and “kangaroo care” (skin-to-skin contact), and helping the mother maintain her milk supply. Although fresh milk is best, expressed breast milk can be stored in a subzero freezer for 6 months to 1 year. Despite the usual assumption that bottle feeding is easier than breastfeeding, the latter provides the infant with more control over milk flow and suck-swallow-breathe coordination, which usually develops between 34 and 36 weeks of gestational age. In addition, breastfeeding requires active suckling and participation of the infant, while bottle feeding can be passive and is associated with increased apnea and lower oxygen saturation.

Providing a quiet, comfortable, and private setting can help both mother and baby make the transition to breastfeeding. Tools that can aid in successful breastfeeding include nipple shields, which help the baby latch onto the breast and increase milk intake, and electronic scales, which provide the best measurement of milk intake in preterm infants through pre- and postfeeding weights.

STAFFING THE NICU: WHAT THE FUTURE HOLDS

Dianne S. Charsha, RNC, MSN, NNP

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The development of neonatal intensive care has reduced mortality and improved long-term outcomes for premature and ill newborns, and the number of NICUs and neonatologists has risen dramatically in the past 30 years (2). Although the number of births has remained relatively constant, the number of preterm births has risen by 27% in the past 20 years, and the number of multiple births has increased by 45% over the past 10 years (3).

With the demand for NICU beds remaining high, how will these units be adequately staffed in the future? Ms. Charsha discussed some of the factors that will affect the supply and demand of qualified staff:

- *Neonatologists.* As of 2001, the average age of working neonatologists was >50 years. As this group nears retirement age, many of their potential replacements currently in medical school are women, who are more likely to balance child rearing with part-time employment.
- *Residents and fellows.* NICU rotations during pediatric residency vary between 3 and 6 months. Over the past 10 years, the partnering of residents and neonatal nurse practitioners has proven to be an effective method of residency training. In July 2003, limits on work hours for residents were implemented (no more than 80 hours per week and no more than 30 consecutive hours on duty), reducing time spent in the NICU.
- *Neonatal nurse practitioners.* Reduced work hours for residents and expanded roles in neonatal care have increased the demand for these advanced practice nurses. In 2002, 170 students graduated from neonatal nurse practitioner programs, and recruiters believe this number should be tripled. In 2003, 3300 neonatal nurse practitioners held current certification.
- *Pediatric hospitalists and physician assistants.* These professionals help fill staffing gaps in newborn nurseries, grower/feeder nurseries (level II NICUs), and follow-up clinics and assist with neonatal resuscitation and stabilization.
- *Nurses.* Over 90% of NICU staff members are nurses, and the average age of registered nurses is >46 years. The nursing workforce is predicted to be >20% below projected need by 2020; stressors that contribute to the nursing shortage include staffing cuts, mandatory overtime, and the use of unlicensed personnel to provide nursing care. Recruitment strategies

are being implemented to help draw student nurses into the NICU and provide additional training. Retention strategies, such as increased salaries and an institutional commitment to quality care, are also needed to stem the looming shortage of qualified nurses.

NEONATOLOGY FROM 30,000 FEET

Reese H. Clark, MD

Pediatrix Medical Group, Inc., Sunrise, Florida

Dr. Clark's role as director of research for Pediatrix Medical Group involves assessing the variability of care within a unit and between units nationwide. His goal is to decrease variability and move toward a model of evidence-based care in neonatology. By stepping back and providing a more distant overview, Dr. Clark offered a different perspective on respiratory support, nutrition, and the prevention and treatment of neonatal sepsis—important areas of clinical research.

Neonatal studies tend to be underpowered and involve small numbers of patients. By comparing practices and outcomes at NICUs across the nation instead of locally or regionally, data (including rare events) are accumulated quickly, and meaningful differences can be identified. Dr. Clark cautioned that much evidence used to change practice is not at a high level; instead change is often driven by consensus opinion. The best evidence comes from multiple randomized trials. He recommended the Cochrane Library as the best source of metaanalyses.

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