Commentary

Neonatal Technology, Perinatal Survival, Social Consequences, and the Perinatal Paradox

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ABSTRACT

Exogenous surfactant therapy for premature infants with respiratory distress syndrome has had a significant impact on infant mortality and on some complications of prematurity. Yet the total number of low-birthweight infants has not declined, resulting in a high-risk population who would require surfactant therapy and long-term child care. Surviving low-birthweight infants (despite surfactant therapy) remain at risk for the consequences of premature birth, such as neurosensory impairment, cerebral palsy, and chronic lung disease. In addition, because of the close association between poverty and low birthweight, surviving premature infants are at increased risk for the new morbidities such as violence, homelessness, child abuse and neglect, and addictive drug use. A goal should be to reduce the risk of being born with a low birthweight, rather than having to treat the consequences of premature gestation.

Despite the marvelous advances that permit us to treat respiratory distress syndrome, the continuing high low-birthweight rate places a significant strain on our health care system. The goal should be redirected to identifying large population-based efforts to reduce the number of low-birthweight infants. (*Am J Public Health.* 1995;85:909–913)

Introduction

The "bench-to-bedside" translation of biomedical research to lifesaving therapy has heralded a new era in the care of premature infants with respiratory distress syndrome.[1,2] Almost 30 years after the discovery of pulmonary surfactant, exogenous surfactant therapy of respiratory distress syndrome was approved for investigational and, subsequently, general use for the prevention and treatment of respiratory distress syndrome. This marvelous example of the beneficial application of basic science research has produced a robust effect by reducing the mortality from respiratory distress syndrome among premature infants.[3–7]

This remarkable improvement in the treatment of sick premature infants must be balanced by less favorable vital statistics on overall infant health.[5,7] Most infant deaths in the United States are associated with low-birthweight (<2500 g) status.[7–10] Low-birthweight infants have a 40-fold increased risk of neonatal mortality, whereas very low birthweight (<1500 g) infants have a 200-fold increased risk of neonatal mortality.[9] Thus, in 1990, 60% of infant deaths were among low-birthweight infants. Furthermore, the low-birthweight rate has not declined in the United States during the last 15 years.[5–7,10]

The enthusiasm for the remarkable scientific advances in neonatology must be tempered by the significant neonatal, postneonatal, and childhood problems of low-birthweight infants and by the environment in which they are born and to which they return after surviving the hazards of premature birth.[11–13] Technology-driven improvement of infant survival may distract from a more fundamental problem of an unabated low-birthweight rate and the innumerable unaddressed, more intractable adverse social influences on infant health in the United States.

Furthermore, due to excessively large numbers of births of low-birthweight and very low birthweight infants, the United States has an unfavorable overall infant mortality rate. In 1990 the United States ranked 20th in infant deaths and 31st in the low-birthweight rate compared with other developed countries.[14] This discrepancy between individual survival and overall position of the health of our infants creates the "perinatal paradox" as conceptualized by Rosenblatt, who stated, "The basic incongruity in American perinatal care lies in our superb ability to care for the individual patient and our dismal failure to address the problems of the larger society."[13(p158)]

Evidence of New Technology

Surfactant's Effectiveness

More than 35 randomized trials demonstrated favorable results after the use of exogenous surfactant among infants with respiratory distress syndrome.[1,2] The therapy consists of artificial or animal-derived surfactant (a combination of lipids with surface tension–lowering properties) being administered through an endotracheal tube directly into a newborn's lung, usually within minutes to hours after birth. Most studies demonstrated a 30% to 40% reduction of overall mortality and possibly a 50% to 60%

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reduction of death due to respiratory distress syndrome.[1,2,15–24] In the United States, infant mortality declined from 9.7 to 9.1 per 1000 births, whereas mortality due to respiratory distress syndrome declined from 86.6 to 59.1 per 100 000 births. Surfactant therapy, however, did not completely eliminate mortality from respiratory distress syndrome, nor did it affect other common causes of neonatal mortality, such as intraventricular hemorrhage, bronchopulmonary dysplasia, necrotizing enterocolitis, sepsis, and sudden infant death syndrome.[1,16–19] With increased survival of low-birthweight infants, but without a reduction of intraventricular hemorrhage, bronchopulmonary dysplasia, necrotizing enterocolitis, and other serious, chronic sequelae, the overall number of surviving premature infants with chronic morbidities will increase. This situation has led other authors to independently suggest that another equally important alternative is to prevent low-birthweight births.[1,2,4,17]

Provision of antenatal maternal glucocorticoid therapy during premature labor has also enhanced our ability to prevent or reduce the severity of respiratory distress syndrome.[25] The simultaneous use of postnatal exogenous surfactant also enhances the effect of antenatal glucocorticoids. In addition, maternal glucocorticoid therapy has been associated with a reduction of potential neonatal morbidities such as necrotizing enterocolitis, pneumothorax, intraventricular hemorrhage, and possibly bronchopulmonary dysplasia.

Costs

The surfactant therapy may reduce the individual patient's hospital charges by 5% to 25%.[26,27] Nonetheless, the overall effect of having more low-birthweight infants survive is to increase the total costs of caring for these surviving immature infants during the neonatal and postneonatal periods.[2,26,28,29] This effect is especially relevant because the incidence of chronic morbidities such as bronchopulmonary dysplasia, intraventricular hemorrhage, necrotizing enterocolitis, and infection is not reduced by surfactant. Chronic sequelae influence health beyond the neonatal period as low-birthweight infants who have attained school-age status have a three- to fourfold risk of rehospitalization and a greater dependency on the health care system than full-term infants.[30–32]

Neurodevelopmental disability remains a particularly disturbing outcome among low-birthweight and, more specifically, very low birthweight infants. The overall numbers of affected children may increase as the low-birthweight rate remains unchanged and because surfactant therapy increases survival without altering the incidence of bronchopulmonary dysplasia or intraventricular hemorrhage.[33–35] The overall risk of abnormal neurodevelopmental handicaps compared with full-term infants is 3-fold among low-birthweight and 10-fold among very low birthweight infants.[9] Neurobehavioral impairment among very low birthweight infants approaches 25% and includes survivors with mental retardation, cerebral palsy, blindness, or deafness.[36] Additional risk factors for such impairments include bronchopulmonary dysplasia, intraventricular hemorrhage, hydrocephalus, and low socioeconomic status.[36,37] Very low birthweight infants remain a high-risk group for poor school performance, as only 50% do satisfactorily in school, 40% may need to repeat grades, and 20% may need special educational classes.[38,39] The long-term developmental and educational outcomes of surviving very low birthweight infants are also compounded by low socioeconomic status.[30,33,37–40]

Poverty places an excessively high burden on infant health.[11,12,14,40] Low-socioeconomic-status families have a high incidence of infant mortality, low-birthweight births, and very low birthweight births compared with families of higher socioeconomic status.[8,11,41–43] Indeed, it has been proposed that reduction of social class differences could prevent over 50% of postneonatal deaths, as well as a significant number of perinatal deaths.[43,44] Poverty is thought to increase the incidence and severity of adverse neonatal events and to increase the severity of the sequelae.[40] Poverty, therefore, results in a high incidence of low-birthweight infants who, with the modern neonatal intensive care, will survive only to be subjected to the postnatal detrimental effects of poverty.

The annual financial costs of neonatal intensive care in the United States vary from $2.8 to $4 billion. If the incidence of low birthweight were reduced by 1%, the United States could save over $400 million in immediate neonatal intensive care charges and an even greater amount of money if special education and rehospitalization for chronic physical morbidities associated with low birthweight could be avoided.[2,45]

New Morbidities Threatening Infant Health

The health, well-being, and development of low-birthweight infants are continuously threatened during pregnancy, infancy, and childhood by new and serious morbidities such as the acquired immunodeficiency syndrome (AIDS) and other congenital sexually transmitted diseases, violence, tuberculosis, lead poisoning, homelessness, parental unemployment, teenage and single-parent families, illicit drug use, and poor educational attainment.[12,14,46–52] These risks to child health result in increased numbers of low-birthweight infants, as exemplified by the strong association of maternal cocaine use with both preterm and low-birthweight births.[48–51,53]

Postneonatal infant deaths are heavily associated with social factors. Despite a decline in the most recent infant mortality rate, there has been a rise of the postneonatal mortality rate in the United States.[5] Some of this excessive postneonatal mortality has been attributed to potentially preventable diseases such as infantile diarrhea.[54,55] It is tragic that many of these infants may have survived the critical illnesses associated with prematurity only to die later of diarrhea. Other infectious diseases threaten inner-city children; for example, the rate of tuberculosis is now increasing among urban, minority children. This epidemic of tuberculosis has been directly tied to public health issues such as poverty, drug use, AIDS, and homelessness.[46]

Violence is an increasing morbidity that affects children directly if they are subjected to child abuse or gang violence and indirectly if they are silent witnesses left with the psychological implications of posttraumatic stress syndrome.[12,14,52,56–58] In 1991, 2.7 million abused or neglected children were reported to child protection agencies.[14,58,59] The homicide rate between 1960 and 1988 among 15- to 19-year-olds increased from 4.0 to 11.7 per 100 000.[12] This increased rate of pediatric homicides is predominantly from firearm-related deaths, accounts for the overall increase in deaths of urban older children in recent years, and represents the leading cause of urban death among Black children between 15 and 19 years of age.

The presence of neonatal intensive care units capable of saving the smallest, most immature neonates, side by side with social and environmental conditions that jeopardize the surviving infant's health, is an example of the perinatal paradox. An

extension of this paradox is noted by our poor ability to prevent deaths from common childhood illness such as diarrhea and measles and our inability to enroll pregnant women into early prenatal care.

Possible Solutions

In the United States today there are over 14 million poor children, representing 20% of all children in the country.[11,14] The number of children without health insurance has increased from 12.7% to 17.8% of all children in the last decade, leaving at least 3.1 million children without health insurance.[60] Children who lack insurance at some time in a year increased from 17.5% in 1977 to 23% in 1987.[60]

The adverse effects of low socioeconomic status on infant health remain a dominant determinant of child health.[40–43] Poverty is often compounded by race; Black infants have poorer health than White infants, even when socioeconomic status is controlled.[41,61–64] In addition, careful analysis reveals that Black families often have lower salaries and greater social risks than White families of similar employment status.[11,62–64] Furthermore, the twofold excess of low birthweight and infant mortality among Black infants compared with White infants is not universal, as it is not evident in Cuba.[41] The disadvantaged health status among Black infants is further exaggerated in highly segregated cities, suggesting that racial health inequalities are, in part, due to racism.[41,64]

Attempts to reduce social inequalities have successfully narrowed, but not eliminated, the health status discrepancies between social classes.[42,43] Confounding factors that continue to contribute to social class differences in health outcome in Sweden and other countries include the personal health characteristics of the mother (e.g., cigarette smoking). The ability of culturally sensitive education and health promotion campaigns to reduce these poor health habits has been successfully demonstrated in Sweden and less developed countries such as Kerala, India.[8,41] The latter location is one of the poorest in India, but because of a high maternal literacy rate, it has a relatively low infant mortality rate.[8]

Improving access to health care is an important first step in reducing the social inequality and excessive infant mortality among the poor in the United States.[8,11–13,41,43,61,65] Universal access to free and comprehensive preconception, prenatal, and infant care has been proposed to be a cost-effective solution toward reducing the low-birthweight and infant mortality rates. The cost savings of initiation of prenatal care for Whites in the first trimester would be $31 for each life saved, in contrast to the cost for a neonatal intensive-care unit hospitalization for a low-birthweight infant survivor ($2834 in 1984).[65] The respective costs for Black infants would be $39 for prenatal care in the first trimester and $2150 for a low-birthweight survivor hospitalized in a neonatal intensive care unit. A laudable goal, which would solve the perinatal paradox and remain budget neutral, would be to provide universal access to health care for women and children by gradually reallocating spending from neonatal intensive care units to accessible and acceptable prenatal care services. Providers would receive specific capitated funding for each healthy child. This would enable providers to choose the less expensive prenatal care option and redistribute resources to preventive services.[13]

Unfortunately, universal access to health care alone is not sufficient to produce a reduction in the infant mortality rate, nor will it remove inequalities among social classes.[11,66] Despite the presence of a National Health Service in Great Britain, major differences remain in health outcome status among children of lower-socioeconomic-status parents compared with those from higher-income families.[65] Furthermore, despite careful evaluation of various states' attempts to expand Medicaid eligibility among poor women, there has been little or no perceivable change in the use of prenatal care services or birth outcomes of poor women involved in these programs.[67–70] If universal access to prenatal and pediatric care is to effectively improve maternal, neonatal, and child health, providers and patients also need to change their health care practices and beliefs.[11] Educational programs that address the importance of prenatal care have been successful in other countries, whereas those that emphasize risk reduction (cigarette use) have been successful in various, but not all, populations.[8,11] Changing the culture (or behaviors) of the most refractory and difficult-to-reach patients in the underclass will be a particularly difficult task.[11]

In addition to changing personal characteristics that place the individual mother at risk for low-birthweight births, universal access to care must be accompanied by a national policy shift, as proposed by Fuchs and Reklis and as initially demonstrated first in Haguenau, France, and later in all of France.[12,71,72] Fuchs and Reklis propose that purchases of social and health goods and services be redistributed toward children.[12] Between 1960 and 1988, federal, state, and local government purchases of goods and services for children increased only 2.95% per year; in comparison, the rate for adults was 5.21% per year. To help reduce child poverty, Fuchs and Reklis also propose a more social-based approach to benefit parents, which includes paid parent leave, subsidized child care, tax credits, and child allowances.

Papiernik et al. have been strong advocates for such social-based assistance.[71,72] The program they described included social and medical-based interventions and successfully reduced the incidence of premature birth in Haguenau and, after becoming national policy, in all of France during the 1980s. This program ensures universal access, organizes regional prenatal care clinics, provides patient education about signs of premature labor and how to reduce the triggers of such labor, and provides social-based interventions. Prenatal care visits are used to carefully monitor signs of premature labor or cervical dilation and to provide education to avoid the events that trigger uterine contraction. Educational advice also attempts to reduce high-risk behavior such as cigarette, ethanol, or illicit drug use. If physical or emotional stresses are triggers for premature uterine contractions, allowances are made to reduce physical work on the job or at home. Thus, prenatal work leave with monetary incentives is provided; mothers may leave work at 34 weeks of gestational age in France (other European countries begin at 28 weeks). Furthermore, mothers receive financial grants if they begin prenatal care before the end of the third month of pregnancy.[71,72]

Summary

The success of surfactant therapy is a marvelous biotechnologic advancement for modern neonatology. However, this success should not be a distraction from the ongoing personal, social, and financial costs of not resolving the perinatal paradox. Interventions and resources need to be redirected toward front-end preventive services and ensuring that the financial, cultural, and educational barriers to care are removed. □

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