NEONATOLOGY — FUTURE TRENDS AND DEVELOPMENT

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INTRODUCTION

Development and innovation in neonatology-perinatology over the past 30 years have taken place at a rate which is unparalleled. Considerable progress has already been made in unravelling the problems of the fetus and newborn. However, it remains that one third of the deaths in childhood take place in the first day after birth and perinatal mortality is as great as that for deaths from all causes during the next 28 years. These deaths give but an inkling of perinatal morbidity and long term handicap. To have a realistic expectation of future trends and development in neonatology, one must first have an understanding and overview of past achievements and errors.

LESSONS FROM THE PAST

Studies in children born before 1950 generally showed that newborn infants with serious disorders usually died, and those who survived were the ones who had to contend with the least perinatal complications, and their long-term prognosis was often good. Neonatology then entered a second phase. As the mortality of low birthweight infants decreased, a large proportion of the survivors were shown to have major handicaps. Reports in the 1960s drew rather depressing conclusions, for they described

results in an era when mental retardation, cerebral palsy, blindness, and deafness did affect between 30% to 80% of very low birthweight (VLBW) survivors. At that time, little was known of the disease mechanisms to which treatment was applied. Many mistakes were made as a result of pioneering enthusiasm for new treatments introduced without scientific evaluation of possible benefits or adverse consequences. Examples included retrolental fibroplasia from oxygen overexposure, increased mortality and spastic diplegia from oxygen restriction, starvation hypoglycaemia, induced hypothermia, and sulphonamide, chloramphenicol and water soluble vitamin K therapies. Furthermore, it was an era where professional skills and sufficient personnel were lacking. The whole concept of providing intensive care to small or sick newborn infants came into question, with good reason, at that time.

We are now into a third phase in the development of neonatology, in which we have a better understanding of the mechanisms of perinatal disorders and advanced technological methods of treatment. We also saw the development of regional organisation of perinatal services. This involves the designation and proper funding of neonatal intensive care units (NICUs) in major hospitals, establishment of a regional neonatal emergency transport service, and the linkage of clinical and educational activities between the regional NICUs and other hospitals with a maternity service in the region. The significant improvement in survival recorded for VLBW infants has been of major importance in reducing the overall neonatal mortality rate. The development of perinatal care in the last 10 years has been associated not only with this improved survival, but also with a reduction in the incidence of handicapping sequelae. All recent reports on follow-up of VLBW survivors agree that the prognosis for major handicaps has improved to an incidence of between 10% to 30%. Further major advances in neonatal intensive care will inevitably take place, but given the potential hazards associated with any innovation, each must be closely scrutinised. Rigorous scientific evaluation of new policies prior to their recommendation is needed to avoid the widespread use of ineffective or hazardous treatments in neonatal intensive care.

PERSONNEL REQUIREMENTS IN NEONATOLOGY

It is imperative that more paediatricians specialise and work full-time in the field of neonatal-perinatal paediatrics. Neonatologists have a role in establishing medical policies, reviewing biomedical equipment requirements, teaching nurses and resident medical officers, maintaining high standards of care and medical auditing, and providing care for preterm or sick newborn infants, often in consultation with general paediatricians as well as paediatric system subspecialists. A neonatal intensive care unit (NICU) should be directed by such a neonatologist who is a paediatrician with special expertise in fetal and newborn medicine, organisation of neonatal follow-up, active research interests, and administrative and educational skills including all aspects of a regionalised perinatal system.

Estimates of personnel requirements are based on the three-level care system now generally accepted (1). Level III (intensive) care is required by 40/1000 livebirths and Level II (intermediate and continuing) care is required by 70/1000 livebirths plus 30/1000 graduates of Level III. For a livebirth population of 40,000/year, for example, the total number of neonates requiring Level III care would be 1600/year. Given an average stay of 10 days, the average daily census would be 44 patients. It has been estimated that there should be one neonatologist for every 6-10 Level III inpatients (1, 2). Therefore, in the above example, 4-7 neonatologists would be required. Estimating needs for neonatologists in Level II care generally adds another 50% to the Level III requirement. Therefore, a total of about 10 neonatologists would be required for a regional programme which has 40,000 livebirths/year. This estimate does not attempt to quantify nonservice time (teaching, administration, research).

Adequate numbers of competent staff are also required at resident medical officer and nursing levels. Neonatal mortality and morbidity have been correlated with staffing levels of both doctors and nurses (3,4). A change to 12-hour shift systems for our neonatal medical officers have contributed to an improvement in the quality of care without an increase in staff salaries. NICU nurses are increasingly replacing resident medical officers in a variety of roles (5,6). Looking into the future, the evolution toward the expanded role of NICU nurses must be flexible enough to allow for innovations while at the same time meeting the needs of educational standards and service responsibility (7). Adequate nurse to patient ratios according io internationally accepted standards are 1:1 to 1:2 for intensive care, 1:3 to 1:4 for intermediate care and 1:5 to 1:6 for convalescent care.

ASSESSMENT OF MORTALITY AND MORBIDITY TRENDS

It is vitally important to maintain a system of perinatal mortality review as a basis for improving neonatal care. The review should be orientated toward a clinical rather than a pathological cause of death, with particular emphasis on the identification of avoidable factors contributing to mortality (8). Although it has been found that one-third of the current decrease in neonatal mortality rate was attributable to a reduction in prematurity, two-thirds were directly associated with improved care (9). Early diagnosis and intervention for perinatal asphyxia and the establishment of regional NICUs have been found to be the main factors in this overall improvement (10). Proper and comprehensive hospital and regional perinatal mortality review committees need to be established to monitor birthweight or gestation specific perinatal mortality rates and avoidable factors contributing to such mortality.

In addition, all at-risk neonatal survivors require cohort-based, serial, systematic and detailed examinations to identify possible physical, neurological, sensory, developmental or social-behavioural disability. Follow-up programmes are an integral part of a perinatal service as they provide a basis for outcome surveillance and evaluation (11). Perinatal conditions which may identify a significant number of infants at risk include VLBW, small-for-gestational age, perinatal asphyxia, neurological complications (seizures, periventricular haemorrhage, meningitis), hyperbilirubinaemia, specific genetic/dysmorphic/metabolic disorders, and psychosocial abnormalities. Follow-up should be effected by a multidisciplinary team that includes a developmental paediatrician, psychologist, nurse co-ordinator and social worker. Early identification, intervention, support, stimulation and education may improve the adaptation of families and children with specific medical or psychosocial problems. Funding should be allocated to long-term follow-up services by the government, separate from the usual busy outpatient clinic where only a token and inadequate service is provided. Only in this way can meaningful and complete information be obtained.

PROGRESS THROUGH REGIONALISATION

The effect of a neonatal intensive care programme on the entire population within the region which it serves depends very much on its availability through regionalisation of perinatal services and on educational efforts in disseminating information to both professionals and lay public. The contention that infants are dying unnecessarily or suffering permanent damage as a result of inadequate care is certainly true. The Consultative Council on Maternal and Perinatal Mortality and Morbidity in Victoria reported that avoidable factors were present in nearly one quarter of all stillbirths with deficiencies identified in both the antenatal period and in the management of labour (12). Furthermore, one in ten neonatal deaths had one or more avoidable factors including a delay in recognition and treatment of sepsis, a delay and failure to transfer the infant, and inadequate resuscitation, paediatric care or management of respiratory distress. A recent study of all livebirths $<$ 1000 g in Victoria showed that those born outside the three tertiary centres had almost twice the mortality rate and over three times the handicap rate compared with those born in the three centres with a NICU (13, 14). Physicians who trained before the introduction of regional care for mothers and infants have not been exposed to neonatal intensive care and are unconvinced of the recent improvements. A survey of doctors has shown that over half of the respondents had a falsely pessimistic view of neonatal outcome, a factor which could influence the counselling they provided parents as well as their initial treatment and referral of mothers and infants (15). There is always a lag between knowledge acquired in tertiary centres and its application on a regional basis. The education needed to facilitate a change in attitudes and habits is tremendous (16).

Regionalisation implies the development, within a geographic area, of a health care system in which, by co-ordination between hospitals and physicians in both the public and private sectors and based on population needs, the degree of complexity of perintal care each hospital is required to provide is determined. For regionalisation to work, it must be emphasised that the grading refers not to the quality, but to the intensity of care to be provided. Each component of the regional system must provide the highest quality of care, but the degree of complexity of patients' needs determines where, and by whom, the care should be provided. The delivery of perinatal health care on a regional basis has been shown to significantly reduce perinatal mortality and morbidity. For neonates who require intensive care, the benefits of properly supervised transport carried out by a specialised Neonatal Emergency Transport Service have been shown to outweight the risks, when outcomes are compared with those neonates kept at facilities unable to provide such care or transported under suboptimal conditions. Studies also showed that early diagnosis and management of obstetric problems are beneficial to the fetus. Furthermore, maternal-fetal transport to ensure neonatal intensive care at birth further improves neonatal outcome. Maternal-fetal transport is more cost-effective than neonatal transport.

THE EXTREMELY LOW BIRTHWEIGHT INFANT

In the State of Victoria, the perinatal mortality rate was 7.13 and the neonatal mortality rate was 2.83 per 1000 births for infants over 1000 g in 1983 (12). However, if extremely low birthweight (ELBW) infants 500-1000 g were included in the statistics, the mortality rates would have increased to 12.77 and 5.48 respectively. Although it is estimated that only 0.3% of all births are ELBW, they comprise 38% of perinatal deaths. In the 1960s, neonatal care was provided only to infants weighing $>$ 1500 g at birth because smaller infants were considered nonviable. Over the subsequent decade, the limit was reduced to 1000 g. Currently, most infants over 500 g are offered neonatal intensive care.

At Queen Victoria Medical Centre (QVMC), all normally-formed livebirths born at 24 weeks gestation or over 500g have been provided with neonatal intensive care since 1977. In our experience, infants of 1000-1499 g are of no major concern, because both their mortality and disability rates are below 10%. If we could arrange for all infants to be born above 1000g or 30 weeks gestation, much of the perinatal mortality and morbidity would be eliminated. However, during the 7-year period 1977-1983, we delivered 94 ELBW stillbirths and 220 ELBW livebirths at QVMC and admitted 41 ELBW outborn referrals. The 1-year survival of our 261 ELBW infants, corrected for 10 major congenital malformations, was 4/36 (11%) at 500-599g, 10/40 (25%) at 600-699g, 23/44 (52%) at 700-799g, 45/74 (61%) at 800-899g, 38/57 (67%) at 900-999g. The overall survival rate of inborn infants would have increased from 47% to 57% if deaths in the delivery room prior to admission to the neonatal unit were excluded and to 62% if neonatal survival only was reported. Among inborn infants, 44% were male, 11% were small-for-gestational age (SGA) and 14% were multiple births. Significant differences in survival were found between males and females (39% vs 53%), SGA and AGA (76% vs 43%) and multiple and singleton births (21% vs 51%). Of the deaths, 64% occurred within 24 hours and 79% within 1 week, indicating that we need not expect many to suffer a prolonged treatment course only to die after futile attempts and massive resources have been expended in an attempt to save them.

Of our 110 ELBW hospital survivors from 1977-1982 who are at least 2 years old, corrected for prematurity, there was 1 post-discharge death and 1 was lost to follow-up. Disabilities defined as cerebral palsy, blindness, sensorineural deafness and developmental delay (Mental Development Index$<$2SD on Bayley Scales of Infant Development) were found in 28% of 108 ELBW survivors (33% at 500-599g, 29% at 600-699g, 29% at 700-799g, 27% at 800-899g, 31% at 900-999g). It is therefore reassuring that survival of those in the lower weight groups was achieved without an increase in disability rate in the smallest survivors. The disability rate was higher in those who were male (38% vs 25%), SGA (40% vs 25%) or multiple births (67% vs 24%).

Although technological advances have contributed enormously to the improved prognosis, it can be dangerous in situations where professional skills and personnel are lacking. Adequate provision of perinatal care for these infants must be made while social and obstetic measures are taken to reduce the incidence of prematurity. Otherwise, restrictions in resources and facilities would result in partial applications of many modern methods of management which, during the development of neonatal intensive care in the past decades, has been shown to dangerously increase the handicap rate. It is equally important to be able to distinguish between the potentially normal and the irreversible abnormal infants. In the latter case, prevention of death inevitably leads to more handicapped survivors. In the former, there is a fine balance between death, handicap and intact survival which, with quality care, can result in more health survivors. The necessary neonatal resources must be provided for the care of these ELBW infants who are potentially normal at birth and who rely on adequate facilities to protect them from death or permanent damage in the first few weeks after birth.

ECONOMIC EVALUATION OF NEONATAL CARE

With the current escalation of health care costs in all fields medicine in the face of finite resources even in the most affluent countries, economic evaluation is required to determine the efficiency of neonatal intensive care and to compare it with other health care programmes with regard to their economic viability. A proper economic evaluation compares survival and quality of survival and actual health care costs, before and after the introduction of a regional neonatal programme (19). It has been documented in a Canadian study that neonatal intensive care increases both survival prospects and costs, as is the case with practically all medical services (20). Cost-benefit analysis in VLBW infants has shown that neonatal intensive care resulted in an actual net economic gain for infants weighing 1000-1499g but a net economic loss for those below 1000g, at least back in 1976 when the study was conducted. The question from a social perspective is how much society is willing to pay for the improved healthy outcome in ELBW infants who are one of the remaining stumbling blocks in improving neonatal mortality.

Direct comparisons of neonatal with other health care programmes should be made with caution because of methodological differences between studies. Nevertheless, rough comparison are possible (21). Costs per quality-adjusted life-year in 1983, adjusted to US dollars, were US$1,220 for antepartum anti-D therapy; US$4,500 for neonatal intensive care in infants weighing 1-1.5 kg at birth; US$6,300 for thyroid screening; US$9,400 for the treatment of severe hypertension; US$19,100 for the treatment of mild hypertension; US$27,000 for oestrogen therapy in women after menopause; US$31,800 for neonatal intensive care in infants weighing 0.5-1 kg at birth; US$36,300 for coronary artery bypass surgery; US$37,000 for the school tuberculin-testing programme; US$47,100 for continuous ambulatory peritoneal dialysis; and US$54,000 for hospital haemodialysis. Furthermore, it has been shown that the cost-effectiveness of neonatal intensive care is much more favourable than the intensive care of critically ill adults (22), although no comparable regional evaluation has been carried out for adult intensive care. Clearly, neonatal intensive care of infants weighing 1-1.5 kg at birth is placed very favourably in relation to the cost-utility of other health programme. Although for those weighing under 1 kg at birth, the cost-benefit of neonatal intensive care was not as encouraging, it is by no means the least rewarding. Criticisms concerning the cost of neonatal intensive care are unjustified when we are able to make comparisons with the other health programmes listed above. Furthermore, comparable costing of other therapeutic modalities, such as surgery for neural tube defects, cardiac, bone marrow and liver transplantation, cancer therapy, geriatric programmes and spinal units, has not been reported, although they are currently being encouraged and supported by society even when they undoubtedly consume considerably more resources than they save or create. As new advances in neonatal treatment and innovations in technology continues to develop in the future, all costs and trends in outcome need to be monitored to maintain its accountability for the health dollars spent.

CONCLUSION

The needs of neonatal patients and their families must receive a high priority. The most valuable resource that any nation has is its young. A national commitment to improve care to our mothers and infants is required. Professionals alone cannot accomplish the enormous task of improving perinatal mortality and morbidity. Both government and personnel involved in regional perinatal care must examine services that function at a less than optimal level, as measured by carefully documented patient outcomes, and explore new and innovative approaches. Neonatology must be expanded and enriched vigorously to ensure the highest quality survival of our most cherished national resource. We can no longer afford either financially, or in terms of human suffering, the cost of failing to give each future generation the safest possible start in life.

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