ORIGINAL ARTICLES

The Neonatal Intensive Care Unit at the University Hospital of the West Indies

The first few years' experience

H Trotman

ABSTRACT

A retrospective analysis of neonates admitted for ventilatory support to the neonatal intensive care unit at the University Hospital of the West Indies between August 2001 and December 2004 was conducted. One hundred and thirty-eight neonates fulfilled criteria for admission into the study. Ninety-eight (71%) were inborn, 88 (64%) survived and 50 (36%) died. The median age at death was 72 hours and 72% of non-survivors died within one week of life. The main reasons for admission into the unit were respiratory distress syndrome 87(63%), followed by hypoxic ischaemic encephalopathy 15 (11%), surgical indications 13 (9%) and meconium aspiration syndrome 11 (8%). Babies with meconium aspiration syndrome and surgical problems had the best survival 82% and 85% respectively. Survival rates increased with increasing birthweight and gestational age. The most common complication seen was air leaks. The judicious use of neonatal intensive care measures in a developing country can result in a reduction of morbidity and mortality. However to maximize on benefits versus cost in an atmosphere of budgetary constraint evidence based management policies and protocols must be developed and implemented.

La Unidad de Cuidados Intensivos Neonatales del Hospital Universitario de West Indies

Primeros años de experiencia

H Trotman

RESUMEN

Se llevó a cabo un análisis retrospectivo de recién nacidos ingresados para recibir soporte respiratorio en la Unidad de Cuidados Intensivos Neonatales (UCIN) del Hospital Universitario de West Indies, entre agosto de 2001 y diciembre de 2004. Ciento treinta y ocho neonatos cumplieron con los criterios de admisión al estudio. Noventa y ocho (71%) fueron pacientes inborn, es decir, nacidos en el mismo hospital, 88 (64%) sobrevivieron y 50 (36%) fallecieron. La edad promedio de muerte fue 72 horas y el 72% de los que no sobrevivieron murió en el transcurso de la primera semana de vida. Las razones principales de ingreso a la unidad fueron el síndrome de insuficiencia respiratoria 87(63%), seguido por la encefalopatía hipóxica isquémica 15 (11%), indicaciones quirúrgicas 13 (9%) y el síndrome de aspiración de meconio 11 (8%). Los bebés con síndrome de aspiración meconial y problemas quirúrgicos, tuvieron los mejores índices de supervivencia – 82% y 85% respectivamente. Las tasas de supervivencia experimentaron un incremento proporcional al aumento del peso al nacer y la edad gestacional. La complicación más comúnmente observable fue el escape de aire. El uso juicioso de medidas en el cuidado intensivo neonatal puede traducirse en una reducción de la morbilidad y la mortalidad. Sin embargo, a fin de maximizar los beneficios frente a los costos en una atmósfera de limitaciones presupuestarias, se hace indispensable implementar y desarrollar políticas y protocolos de administración basados en evidencias.

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INTRODUCTION

There has been a dramatic fall in neonatal mortality in developed countries with the advent of mechanical ventilation and the concept of neonatal intensive care (1–3). The decrease in mortality has been even more impressive for very low birthweight infants (< 1500g) (4–6). This has been attributed to the increased availability of mechanical ventilation, and more recently the introduction of surfactant and total parenteral nutrition (7, 8).

The improvement in survival is not only related to the availability of intensive care but also the level of intensive care (9). Paneth *et al* have demonstrated a direct proportional decrease in mortality of low birthweight singletons with intensity of care received (10).

The benefits of neonatal intensive care are clear but provision of this intervention is labour intensive and requires a major financial expenditure that is not entirely recoverable. In developing countries where budgetary constraints limit technological advances, the judicious implementation of neonatal intensive care measures can result in reduction of morbidity and mortality. This study seeks to review the outcome of neonates ventilated in the newly established neonatal intensive care unit (NICU) at the University Hospital of the West Indies (UHWI) to establish patterns of utilization of the facility in order to institute appropriate resource planning and management to facilitate the sustainability of the unit.

SUBJECTS AND METHODS

This was a retrospective, descriptive study looking at all neonates admitted for ventilatory support to the NICU between August 2001 and December 2004, except those with lethal chromosomal or congenital anomalies and those who were ventilated for less than 12 hours. Study patients were identified from the neonatal unit admission logbook. Patients' dockets were retrieved and data on gender, age at commencement of and duration of ventilatory support, highest ventilatory settings in first 24 hours of ventilation, birthweight, gestational age, diagnosis, complications and outcome were extracted.

The UHWI is located in urban Jamaica and is a university-affiliated institution. This hospital, along with two other public hospitals, serves mainly the population of Kingston and St Andrew, approximately 652 000 people (11).

Neonates admitted to the neonatal unit are mainly inborn; however newborns from other hospitals in the island (both private and public) are often transferred into the unit. The unit also functions as a referral centre for private paediatricians, as well as for the other tertiary level paediatric institution in the city.

The neonatal unit at the UHWI presently has a maximum capacity of 30 beds and the small NICU established in 2001 is a six-bed unit, with the present capability of ventilating only three neonates at any one time. Surfactant is available but due to financial cost is not accessible to most of the babies; total parenteral nutrition is not readily available. Four consultant paediatricians, one of whom has specialist training in neonatology, are responsible for medical care of the neonates. The consultants rotate on a two-monthly basis and when on service have complete responsibility for ventilator management; however, difficult management issues may be referred to the neonatologist.

Neonates were nursed under servo-controlled radiant warmers, continuous non-invasive monitoring of heart rate, respiratory rate, blood pressure, oxygen saturation and temperature was performed. Arterial blood gases were done four hourly or more often when the neonate was unstable, as dictated by the clinical state of the infant. Gases were done less frequently once the neonate stabilized. Blood glucose was monitored twice daily using dextrostix or more frequently if indicated; abnormal values were corroborated with blood glucose estimation on venous samples. A full sepsis work-up was done on infants with clinical signs of sepsis and appropriate antibiotics commenced.

Ventilator settings varied with individual cases but generally the ventilator was set initially at a peak end expiratory pressure (PEEP) of 4–5cm H_2O, peak inspiratory pressure (PIP) of 18–20 cm H_2O, rate of 50/min and an FiO_2 sufficient to maintain O_2 saturation greater than 90%. Adjustments were made based on clinical and radiological signs as well as arterial blood gas values. Neonates were weaned off the ventilator when there was clinical improvement supported by normal blood gases on minimal ventilatory support.

Descriptive analyses were performed; differences in outcome by gender, weight, gestational age, diagnosis, duration of ventilation and year were determined using analysis of variance; Chi-square tests for categorical variables and independent *t* test for continuous variables. Statistical significance was taken at the level $p < 0.05$. Analyses were performed using the Statistical Package for Social Sciences (SPSS) version 11.

The UWI/UHWI Faculty of Medical Sciences Ethics Committee granted approval for this study to be conducted.

RESULTS

During the study period, 159 neonates were ventilated in the NICU, of whom 138 fulfilled criteria for admission into the study. Ninety-eight (71%) were inborn, 76(55%) were male and 62 (45%) were female. There was no difference in mean birthweight and gestational age between the male 2.0 ± 1 kg, 33 ± 4 weeks and female 1.7 ± 1 kg, 31 ± 4 weeks neonates respectively. Figure shows the outcome of babies ventilated in the NICU by year.

Eighty-eight (64%) neonates survived and 50 (36%) died. The median age at death was 72 hours and 36 (72%) of the infants died within one week of life. The babies who died were significantly smaller (1.4 ± 0.9 kg) and less mature (30 ± 4 weeks) than those who survived (2.1 ± 1 kg and 33 ± 4 weeks $p < 0.001$). There was no difference in outcome by gender (48 [63%] males and 40 [65%] females survived) or

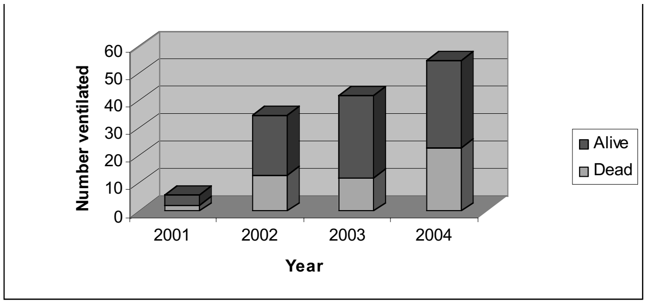

Figure: Outcome of babies ventilated in the neonatal intensive care unit, University Hospital of the West Indies by year.

by place of birth (61 [62%] inborn infants survived and 27 [68%] outborn infants survived). The percentage of outborn babies increased yearly from a low of 17% in 2001 to a high of 37% in 2004.

Table 1 shows outcome of ventilated neonates by diagnosis. The most common reasons for admission were prematurity/respiratory distress syndrome (RDS), meconium aspiration syndrome (MAS), hypoxic ischaemic encephalopathy (HIE) and surgical problems. Babies with MAS and babies with surgical problems had the best outcome (9/11 [82%] and 11/13 [85%] survived, respectively). The two surgical babies died post operatively one had repair of a tracheo-oesophageal fistula and the other a congenital diaphragmatic hernia. The two babies with MAS who died had respiratory failure.

Table 1: Outcome of babies ventilated on the NICU, UHWI by reason for ventilation

Reason for ventilation	Dead (%)	Alive (%)	Total
Respiratory distress syndrome	37 (42)	50 (58)	87
Hypoxic ischaemic encephalopathy	5 (33)	10 (67)	15
Surgical	2 (15)	11 (85)	13
Meconium aspiration syndrome	2 (18)	9 (82)	11
Bronchopneumonia	0 (0)	3 (100)	3
Necrotizing enterocolitis	2 (100)	0 (0)	2
Sepsis	1 (50)	1 (50)	2
Pneumothorax	0 (0)	2 (100)	2
Kernicterus	1 (100)	0 (0)	1
Respiratory distress	0 (0)	1 (100)	1
PPHN	0 (0)	1 (100)	1
Total	**50 (36)**	**88 (64)**	**138**

PPHN = Persistent pulmonary hypertension of the newborn.

Of the 87 neonates with RDS, 22 (26%) received surfactant. There was no difference in outcome between those who received surfactant (13 [59%] survived) and those who did not (75 [65%] survived). The babies with RDS who did not survive were extremely premature and died from respiratory failure. Fifty-three (38%) of the babies began mechanical ventilation within six hours of birth. For babies ventilated during the first week of life, there was no difference in outcome between those ventilated within the first 24 hours and those ventilated after 24 hours (58 [63%] and 24 [77%] survived, respectively).

Outcome by birthweight and gestational age of the neonates ventilated in the NICU is shown in Table 2. Survival improved with increasing birthweight and gestational age ($p < 0.05$). Extremely low birthweight infants weighing less than 1000g were less likely to survive than those weighing greater than 2500g (OR 0.15, CI 0.05, 0.39) and neonates less than 29 weeks gestation were less likely to survive than term infants (OR 0.23, CI 0.09, 0.59).

Table 2: Outcome of babies ventilated in the NICU, UHWI, by birthweight and gestational age

Gestational age (weeks)	Dead (n = 50)	Alive (n = 88)	Total (n = 138)
< 29	30 (54)	25 (46)	55 (100)
30–33	9 (32)	19 (68)	28 (100)
34–37	3 (17)	15 (83)	18 (100)
> 37	8 (22)	29 (78)	37 (100)
Weight (g)			
500–999	25 (64)	14 (36)	39 (100)
1000–1499	14 (41)	20 (59)	34 (100)
1500–2499	3 (12)	23 (88)	26 (100)
$2500	8 (20)	31 (80)	39 (100)

Table 3 shows the mean highest ventilatory settings within the first 24 hours of ventilation by the common reasons for ventilation. There were no statistically significant differences noted. Twenty (14%) neonates experienced complications of ventilation, (Table 4). The most common complication seen was air leaks. Complications were most frequently seen in neonates with RDS; five of these babies had pnuemothoraces, three had pneumonia, two had intra-

Table 3: Mean ventilatory settings in the first 24 hours of ventilation by the most common reasons for ventilation

Reason for ventilation	Mean ± SD PIP	Mean ± SD PEEP	Mean ± SD FiO2	Mean ± SD Rate	Modal age at commencing ventilation (range) days	Modal duration of ventilation (range) days
RDS	20 ± 3	5 ± 0.5	90 ±17	51 ± 9	0.25 (0.25 – 54)	4.0 (0.63 – 75)
MAS	22 ± 5	5 ± 0.6	98 ± 7	51 ± 10	0.25 (0.25 – 8)	2.6 (0.80 – 12)
HIE	20 ± 4	5 ± 0.6	92 ±18	52 ± 7	0.25 (0.25 – 4)	4.0 (0.67 – 29)
Surgical	20 ± 1	5 ± 0.5	87 ±17	50 ± 7	1.00 (0.25 – 18)	4.0 (1.00 – 22)

RDS = Respiratory distress syndrome; MAS = meconium aspiration syndrome; HIE = hypoxic ischaemic encephalopathy
PIP = peak inspiratory pressure; PEEP = peak end expiratory pressure.

Table 4: Outcome of babies ventilated in the NICU, UHWI, by complication

Complication	Dead (%)	Alive (%)	Total
Pneumothorax	3 (33)	6 (67)	9
Pneumonia	0 (0)	3 (100)	3
Chronic lung disease	0 (0)	4 (100)	4
Intraventricular haemorrhage	1 (33)	2 (67)	3
Pulmonary haemorrhage	2 (67)	1 (33)	3
Total	**6 (27)**	**16 (73)**	**22**

Two neonates had more than one complication

ventricular haemorrhage (IVH), four had chronic lung disease (CLD) and two had pulmonary haemorrhage.

DISCUSSION

The survival rate of 64% noted in this study for neonates ventilated in the NICU, though less than that quoted for developed countries (91%) (3) compares favourably with figures quoted for other developing countries (46–54%) (12–14). Differences in mortality of ventilated neonates between developed and developing countries may be related to the ready availability of surfactant and parenteral nutrition in developed countries as compared to developing countries. Limited technical expertise and technological advances in developing countries may also be an added factor.

Analysis of patterns of utilization of the NICU at the UHWI shows that the number of babies and the number of premature babies ventilated has increased yearly. There was no difference in outcome between babies delivered at UHWI and those transferred in from other hospitals; however, the number of babies accepted from other hospitals is steadily increasing. Presently, there exists an informal selection process driven by availability of ventilators, adequacy of nursing staff and the individual consultant's discretion. With the growing demand from other hospitals for ventilatory support for babies, a formal admission policy needs to be developed to ensure the most cost effective utilization of resources.

Respiratory distress syndrome, a condition almost exclusively seen in the premature infant, was the single most common reason for ventilation in the NICU, accounting for 63% of admissions. This finding is similar to other studies (13, 15). The non-survivors in this study were noted to be the smaller, less mature babies, this association of low birthweight and immaturity with poor survival has been documented in other studies (12, 13).

Conditions associated with increased mortality in this study were RDS, HIE, necrotising *enterocolitis* (NEC) and *kernicterus*. This is not unexpected, as RDS is seen primarily in the premature infant and its severity increases with decreasing maturity; decreased maturity is associated with increased mortality. Neonates with NEC who require ventilation are usually severely ill. Hypoxic ischaemic encephalopathy results from anoxic injury to the brain and the prognosis for severely affected infants who would be the ones requiring ventilation is extremely poor, this is also true for neonates with *kernicterus* in whom the toxin bilirubin is deposited in areas of the brain. A defined policy for initiation and withdrawal of ventilation needs to be developed for neonates in whom the probability of severe long-term neurodevelopmental deficits is high.

The mortality rate in this study is complicated by these infants who have a poor prognosis by virtue of their primary diagnosis who are placed on a ventilator as part of a terminal resuscitative effort. These infants succumb to complications of their disease process, on which mechanical ventilation may have very little impact. In this study, there were eight such patients five with HIE stage III, one with *kernicterus* and two with severe NEC one of whom had NEC *totalis*.

A multidisciplinary infant bioethics committee consisting of professional and lay members needs to be established. This committee would serve several functions, education of medical staff and families on ethical principles, policy recommendations on issues such as withholding or withdrawal of life support and retrospective and prospective review of cases.

The majority of babies who died did so within a week of being placed on the ventilator. This is an important finding as it means that babies were not being ventilated for extended periods of time and then succumbing to their illness, which would be a drain on resources. Neonates with RDS required the longest duration of ventilation and also had the highest incidence of complications.

From this study, it is seen that the premature infant with RDS places the greatest demand on the resources of the NICU. They have the greatest utilization of ventilation, they are more likely to die, they require more prolonged periods of ventilation and they have a higher incidence of complications. If the NICU at UHWI is to be a financially sustainable entity, the premature, very low birthweight (VLBW) infant has to be targeted. The focus should begin with obstetric measures for the prevention of preterm delivery, close monitoring of high risk pregnancies and judicious use of tocolytics. In addition, the neonatal unit needs to develop a policy for defining age and weight of viability for the unit. This involves looking at survival rates for VLBW infants and determining the weight and gestational cut-off below which access to ventilation has not led to significantly improved outcome in this setting.

Trotman *et al* have shown that below a birthweight of 750g and a gestational age of 27 weeks there has been little impact on mortality by the introduction of mechanical ventilation at the UHWI (16). Taking this into account one possible option would be not to initiate active resuscitation for babies below 750g or 27 weeks if they are not vigorous at birth. For the ones who are vigorous at birth, ventilatory support should be by means of bubble CPAP.

The value of surfactant in improving outcome of neonates with RDS, decreasing the length of ventilation and decreasing the incidence of some complications has been previously documented (17). Although surfactant is available in this setting it is not accessible to the majority of patients because of cost. Means of increasing accessibility of this drug needs to be explored for the future as in the long term, surfactant use will lead to decreased expenditure. The results of studies such as this one can be used to lobby for surfactant to be covered under the National Health Fund thereby making it more widely available in Jamaica.

Another area to be considered is the nutritional needs of the VLBW infants. Nutrition plays a major role in the survival of these infants and the inability to support them totally with parenteral nutrition is a factor that limits outcome. There is a need for the development of a total parenteral nutrition programme in the neonatal unit. Again the results of this study can be used to justify to policy makers the necessity for the inclusion of parenteral nutrition on the hospital formulary.

There is a need for further studies to define predictors of outcome in the VLBW infants, which will guide management protocols and also help in the prevention, identification and management of complications. A perinatal database needs to be established to facilitate tracking of performance of the unit and the conduct of ongoing studies that will provide evidence based data to guide management policies.

The judicious use of neonatal intensive care measures in a developing country can result in a reduction of morbidity and mortality. However, to maximize on benefits versus cost in an atmosphere of budgetary constraint, evidence based management policies and protocols must be developed and implemented.

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