The Impact of the Establishment of a Neonatal Intensive Care Unit on the Outcome of Very Low Birthweight Infants at the University Hospital of the West Indies

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ABSTRACT

A retrospective analysis of the outcome of inborn very low birthweight infants admitted to the neonatal unit of the University Hospital of the West Indies pre- (period 1) and post- (period 2) establishment of a neonatal intensive care unit was conducted. During the study, 250 infants were admitted to the neonatal unit, 132 (53%) during period 1 and 118 (47%) during period 2. There was improved survival during period 2 when 81 (69%) infants survived compared to period 1 when 73 (55%) survived (p = 0.02). This increased survival was due to an increase in survival of infants weighing 750 – 999g in period 2 when 17 (65%) infants survived compared to 9 (29%) in period 1 (p < 0.05). There was an increase in the number of infants ventilated in period 2, 39 (33%) compared to 12 (9%) period 1 (p < 0.001). Infants who were ventilated in period 2 were less likely to die than those ventilated in period 1 (OR 0.05, CI 0.01, 0.66). After controlling for gender, weight, gestational age and ventilation, infants born in the second time period were less likely to die than those born in the first time period (OR 0.33, CI 0.14, 0.76). The establishment of a neonatal intensive care unit has resulted in improved survival of very low birthweight infants; further improvement in survival of these infants will be dependent on increased accessibility to surfactant therapy, initiation of total parenteral nutrition and availability of trained personnel.

Impacto del Establecimiento de una Unidad Neonatal de Cuidados Intensivos en el Estado Clínico de los Recién Nacidos con muy Bajo Peso en el Hospital Universitario de West Indies

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RESUMEN

Se llevó a cabo un análisis retrospectivo del estado clínico de los recién nacidos con peso extremadamente bajo, ingresados en la unidad neonatal del Hospital Universitario de West Indies, antes (período 1) y después (período 2) del establecimiento de una unidad neonatal de cuidados intensivos. Durante el estudio, 250 recién nacidos fueron ingresados en la unidad neonatal: 132 (53%) durante el periodo 1 y 118 (47%) durante el periodo 2. En este segundo período, se produjo un aumento de la supervivencia, al sobrevivir 81 (69%) recién nacidos, en contraste con el primer período, en el que sobrevivieron 73 (55%) infantes (p = 0.02). Este aumento se debió a un incremento en la supervivencia de los infantes que pesaban 750 – 999 g en el período 2, en el que 17 (65%) recién nacidos sobrevivieron, en comparación con el 9 (29%) en periodo 1 (p <0.05). Hubo un aumento en el número de recién nacidos ventilados en el período 1(OR 0.05, CI 0.01, 0.66). Después de ajustar por el sexo, peso, edad gestacional y ventilación, los infantes nacidos en el segundo período de tiempo eran menos propensos a morir que los ventilados en el primer período (OR 0.33, CI 0.14 – 0.76). El establecimiento de una unidad neonatal de cuidados intensivos ha traído como resultado un mejoramiento en la supervivencia de los recién nacidos con un peso extremadamente bajo al nacer. El mejoramiento ulterior de estos infantes dependerá de una mayor accesibilidad a la terapia surfactante, la iniciación de la nutrición parenteral total, y la disponibilidad de personal calificado.

West Indian Med J 2005; 54 (5): 297

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INTRODUCTION

Neonatal mortality, particularly that of very low birthweight (VLBW) infants (*ie* birth weight less than 1500 g) has decreased in developed countries since the introduction of the concept of neonatal intensive care (1–6). The improvement in survival is not only related to availability of intensive care but also level of intensive care (7, 8).

Unfortunately, in many developing countries there is limited or no access to neonatal intensive care measures. Daga and Daga proposed that in the setting of developing countries a model of conservative newborn care – provision of warmth, feeding with breast milk and adequate resuscitation – could reduce neonatal deaths by 55–60% in babies weighing more than 1000 g. The judicial use of oxygen given *via* head box and the initiation of circulatory supportive measures could reduce mortality by a further 15–20% and 7–10% respectively. Hence a less technical, less expensive, less invasive and less labour intensive model of newborn care is a sensible approach for developing countries (9–11).

Other authors, however, have proposed that there is a role for neonatal intensive care units in developing countries but that these should be regionalized, with an organized neonatal transport system, rather than individual hospitals all attempting to develop neonatal intensive care units (12).

Description of the neonatal unit

The University Hospital of the West Indies (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 (13).

Neonates admitted to the nursery are mainly inborn, but as one of two tertiary care paediatric facilities in the urban region, newborns from other hospitals in the island (both private and public) are often transferred to the unit. The unit also functions as a referral centre for some private paediatricians, as well as for the other tertiary level paediatric institution in the city.

The neonatal unit at the UHWI has a maximum capacity of 30 beds and the small Neonatal Intensive Care Unit (NICU) established in 2001 is a 6-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.

Outcome was defined as status at the time of discharge from the main ICU prior to establishment of the NICU and as status at the time of discharge from the neonatal unit post-establishment of the NICU.

With the introduction of a NICU at the UHWI, it is timely to review the survival rates of VLBW infants pre- and post-establishment of the NICU. We hypothesize that survival of VLBW infants post-NICU establishment will be greater than those pre-NICU establishment.

SUBJECTS AND METHODS

Study population

This was a retrospective, descriptive study looking at all inborn VLBW infants admitted to the neonatal unit in the two-year period prior to and after the development of a NICU. Study patients were identified from the neonatal unit/NICU admission logbooks. All VLBW infants admitted to the neonatal unit/NICU during the years 1999 and 2000 and 2002 to 2003 except those with lethal chromosomal or congenital anomalies were included. The year 2001 was excluded as it represented the transition period between ventilating babies in the main ICU and ventilating babies in the NICU. Patients' records were retrieved and data on gender, birthweight, gestational age, diagnosis, outcome, ventilatory support and surfactant administration were extracted.

Prior to the opening of the NICU, nursing and medical staff attended a series of workshops on the care of the ventilated infant, managing the infant on a ventilator and also the mechanics of operating the current ventilators (Infant Star 950™ Tyco Health Care and Puritan-Bennett 840™ Mallinckrodt Inc Tyco Health Care) used in the NICU. Training of staff on the use of the new monitors (Agilent M3046A™ Phillips Medical Systems) for non-invasive measuring of heart rate, respiratory rate, oxygen saturation and blood pressure was also carried out. Medical personnel received training in the use of the IRMA™ blood analysis system International Technidyne Corporation for the determination of arterial blood gasses. A cadre of foreign NICU trained nurses contracted to the UHWI was assigned to the neonatal unit and these nurses were utilized in the NICU. One of the local sisters in charge of the unit was sent on a three month attachment to a NICU in the United Kingdom for updating of skills and on her return she supervised ongoing education of the nurses attached to the unit.

During the first study period, January 1999 to December 2000, babies who needed ventilation were ventilated in the hospital's main intensive care unit (ICU). Neonates were co-managed by the anaesthetists and the consultant paediatricians. The anaesthetists primarily dealt with the ventilatory management of the neonates, while the paediatricians were responsible for the medical management and were the primary physicians. The general ICU is an eight-bed unit that services the entire hospital and at times neonates in need of ventilatory support could not be accommodated due to lack of space or adequate nursing staff. These infants were then managed on the neonatal unit with bubble nasal Continuous Positive Airway Pressure (CPAP). If any of these infants could not be adequately maintained on this mode of ventilatory support, they would usually succumb to their disease process, as no other alternative was available.

Bubble nasal CPAP was administered *via* an endotrachael (ET) tube placed in the nasopharynx, the ET tube would then be connected by way of a 'T' connector to two lengths of tubing. One of the lengths of tubing would be immersed in a bottle containing 1.5 L of water with centimetre gradations on the external aspect and the depth at which it was placed determined the amount of positive pressure delivered to the neonate's airways. The remaining length of tubing would be connected to an oxygen outlet *via* a humidifier and this would deliver humidified oxygen to the neonate. At times, to allow for mixing of oxygen and air, this second tube would be connected to two short lengths of tubing *via* a 'Y' connector, one short tube would then be connected to an air outlet and the other to the oxygen outlet *via* a humidifier. Initially most neonates would be started at a pressure of 5 cm of water; the pressure would then be titrated based on the values of the arterial blood gasses. Generally, pressures of greater than 8 cm of water were never used.

Prior to the establishment of the NICU, because of the decreased probability of infants weighing less than 1000g gaining admission to the main ICU, the degree of resuscitation of any of these infants who were not vigorous at birth was limited by the fact that post resuscitation and stabilization, there was no mechanical ventilatory support to offer them and an infant who is not breathing spontaneously could not benefit from nasal bubble CPAP. After the establishment of the NICU with the increased availability of ventilatory support for these infants, resuscitative efforts could be more aggressive. Also these infants could now be offered the benefit of surfactant (Survanta™ 4mls/Kg) administration. When placed on the ventilator, the usual initial settings were as follows: positive end expiratory pressure of 4 cm H_2O, positive inspiratory pressure of 15-24 cm H_2O, an inspiratory time of 0.4 seconds, a rate of 50/min and a fraction of inspired oxygen sufficient to maintain oxygen saturation above 90%. These settings were adjusted based on the values of the arterial blood gasses. Most infants spent an average of 5–10 days on the ventilator. There was no major change in obstetric practice at the UHWI during the study period. The use of antenatal steroids and the Caesarean section rate were similar during both periods. The VLBW rate for both time periods was 25/1000 live births.

Descriptive analyses as well as univariate and multivariate logistic regression analyses were performed. Statistical significance was taken at the level $p < 0.05$.

The University of the West Indies/University Hospital of the West Indies Faculty of Medical Sciences Ethics Committee granted approval for this study to be conducted.

RESULTS

During the study, 250 VLBW infants were admitted to the neonatal unit, 132 (53%) during period 1 and 118 (47%) during period 2. There were no differences between the two study periods in the weight distribution, gender distribution and reasons for admission. The mean birthweight of infants in period 1 was 1004 ± 272 g (range 500–1490 g) and those in period 2 was 1071± 271 g (range 520–1490 g) $p = 0.06$. Neither were there any differences between the two study periods in mean birthweight and gestational age between the survivors and non- survivors (Table 1).

Table 1: Comparison of characteristics of VLBW infants admitted to the neonatal unit UHWI during the periods 1999–2000 and 2002–2003

Variable	**1999–2000**	**2002–2003**
Total (%)	132	118
Survivors (%)	73 (55)	81 (69)*
Non-survivors (%)	59 (45)	37 (31)*
Males (%)	55 (42)	56 (48)
Females (%)	76 (58)	62 (52)
Total ventilated (%)	12 (9)	39 (33)**
No. babies ventilated – Survivors (%)	1 (8)	20 (51)*
No. babies ventilated – Non-survivors (%)	11 (92)	19 (49)*
Mean bwt ± SD survivors (g)	1156 ± 211	1159 ± 216
Mean bwt ± SD non-survivors (g)	819 ± 219	871 ± 278
Mean gestational age ± SD survivors	30.6 ± 2	30.6 ± 2
Mean gestational age ± SD non-survivors	27.7 ± 2	27.1 ± 2

* $p < 0.05$ ** $p < 0.001$
1 neonate in the period 1999-2000 had ambiguous genitalia

There was an increase in survival rate during period 2 when 81 (69%) infants survived compared to period 1 when 73 (55%) survived ($p = 0.02$) (Table 1). This increased survival was mainly due to an increase in survival of infants weighing less than 1000 g in period 2 when 20 (44%) infants survived compared to period 1 when 13 (22%) survived ($p < 0.05$). The major cause for mortality in both time periods was respiratory failure accounting for 69(95%) of the deaths in period 1 and 72 (89%) of the deaths in period 2. Other causes of mortality in period 1 were three (4%) sepsis and one (1%) Necrotising Enterocolitis (NEC) and in period 2, 1 (1%) sepsis, five (7%) NEC, one (1%) intraventricular haemorrhage, one (1%) pulmonary haemorrhage and one (1%) hypoxic ischaemic encephalopathy.

Table 2: Comparison of outcome by birthweight of VLBW infants admitted to the neonatal unit UHWI during the periods 1999–2000 and 2002–2003

Weight (g)	**1999–2000**			**2002–2003**		
	Dead	**Alive**	**n**	**Dead**	**Alive**	**n**
500–749	25 (86)	4 (14)	29	17 (85)	3 (15)	20
750–999	22 (71)	9 (29)*	31	9 (35)	17 (65)*	26
1000–1249	9 (22)	32 (78)	41	4 (14)	25 (86)	29
1250–1499	3 (10)	27 (90)	30	6 (14)	36 (86)	42
Total	**59**	**72**	**131**	**36**	**81**	**117**

* Fisher's exact test $p < 0.05$
The weight for one neonate in each time period was unknown

There was an increase in the number of VLBW infants ventilated in period 2, when 39 (33%) infants received ventilatory support compared to 12 (9%) in period 1 ($p < 0.001$). Infants who were ventilated in period 2 were less likely to die than those ventilated in period 1 (OR 0.05, CI 0.01, 0.66)

As birthweight and gestational age increased the risk of dying decreased (OR 0.1, CI 0.01, 0.73) and (OR 0.57, CI 0.44, 0.74) respectively. There was a significant increase in survival of neonates weighing 750–999 g in period 2 when 17 (65%) of these infants survived compared to 9 (29%) infants in period 1 ($p < 0.05$) (Table 2). More babies weighing 750-999 g were ventilated in period 2, 12 (67%) than in period 1, 6 (33%) ($p = 0.04$).

There were 111 males admitted during the study periods, 55 (49.5%) in period 1 and 56 (50.5%) in period 2. One hundred and thirty-eight females were admitted, 76 (55%) in period 1 and 62 (45%) in period 2. There was no difference in survival of males between the two time periods; however, there was an increase in survival of females in period 2. Forty-five (73%) females survived in period 2 while 41 (54%) survived in period 1 ($p < 0.05$). Overall, females were less likely to die than males (OR 0.35, CI 0.16, 0.76).

The primary reason for ventilation was Respiratory Distress Syndrome (RDS). Eleven (9%) neonates received surfactant therapy in period 2 of whom 5 (45%) died, while only one baby received surfactant in period 1 and this baby did not survive. Overall for the four-year period, mean birthweight of survivors (1200 ± 200 g) was significantly greater than that of non-survivors (800 ± 200 g) ($p < 0.001$). Mean gestational age was also significantly greater for survivors (30.6 ± 2 weeks) than for non-survivors (27.4 ± 2 weeks) ($p < 0.001$).

Variables affecting outcome were entered into a multivariate logistic regression model, after controlling for gender, weight, gestational age and ventilation, infants born in the second time period were still less likely to die than those born in the first time period (OR 0.33, CI 0.14, 0.76).

DISCUSSION

There was a significant increase in the survival of VLBW infants in the two years post establishment of a NICU at the UHWI. Similar results have been demonstrated in previous studies (1, 3, 5, 6, 14). A greater proportion of neonates requiring ventilatory support had access to mechanical ventilation in the post-NICU period. The outcome of ventilation was also significantly improved in this period. We believe that this was as a result of decrease in the lag time between development of the signs of respiratory failure and commencement of mechanical ventilation. In the period prior to the establishment of the NICU, mechanical ventilation, when available, was reactive or responsive to clinical deterioration rather than pro-active or anticipatory as occurred in period 2. Even after controlling for mechanical ventilation, there was still increased survival of the VLBW infants born post-establishment of the NICU. This reflects the added benefits of neonatal intensive care measures such as better monitoring of the infants, improved medical care by appropriately trained nursing and medical personnel and more timely and appropriate intervention when there is clinical deterioration.

It is not surprising that the improved survival rate was as a result of increased survival of infants less than 1000 g. These infants, because of the immaturity of their lungs, would be at greatest risk of severe RDS and therefore would benefit the most from increased access to mechanical ventilation and neonatal intensive care measures. There was no improvement in survival rates for infants weighing less than 750 g post-introduction of the NICU. Nutrition plays a major role in the survival of these infants and the inability to support these infants with parenteral nutrition prior to initiation of oral feeds and the degree of negative nitrogen balance experienced by them are limiting factors in outcome. During neither study period was total parenteral nutrition available. The use of surfactant has also been shown to improve survival of VLBW infants (15). This treatment modality was not readily accessible during the study periods and for the few infants who received it, it was not administered in a timely manner (within six hours of onset of disease).

The establishment of a NICU at the UHWI has resulted in improved survival of VLBW infants. Further improvement in survival will be dependent on an increase in appropriately trained nursing and medical staff, the accessibility of surfactant and the availability of parenteral nutrition.

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