

Two-year Outcome of Normal-birth-weight Infants Admitted to a Singapore Neonatal Intensive Care Unit

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Abstract

Introduction: To describe the characteristics, the immediate and short-term outcome and predictors of mortality in normal-birth-weight (NBW) infants admitted to a tertiary neonatal intensive care unit (NICU) in Singapore. **Materials and Methods:** We retrospectively reviewed the medical records of 137 consecutive NBW infants admitted to the NICU of the Singapore General Hospital from January 1991 to December 1992. Data on the diagnoses, clinical presentation of illness, intervention received, complications and outcome as well as follow-up patterns for the first 2 years of life, were collected and analysed. **Results:** NBW NICU infants comprised 1.8% of births in our hospital and 40.8% of all NICU admissions. The main reasons for NICU admissions were respiratory disorders (61.3%), congenital anomalies (15.3%) and asphyxia neonatorum (11.7%). Respiratory support was necessary in 81.8%. Among those ventilated, the only predictive factor contributing to mortality was the mean inspired oxygen concentration. The mortality rate was 11.7%. Causes of death included congenital anomalies (43.75%), asphyxia neonatorum (31.25%) and pulmonary failure secondary to meconium aspiration syndrome (12.5%). The median hospital stay among survivors (88.3%) was 11.0 (range, 4 to 70) days. Of 42 patients (out of 117 survivors) who received follow-up for at least 6 months, 39 infants did not have evidence of any major neurodevelopmental abnormalities at their last follow-up visit, prior to or at 2 years of age. **Conclusions:** Despite their short hospital stay (compared to very-low-birth-weight infants), the high volume of NBW admissions make the care of this population an important area for review to enhance advances in and hence, reduce the cost of NICU care. With improved antenatal diagnostic techniques (allowing earlier and more accurate diagnosis of congenital malformations) and better antenatal and perinatal care (allowing better management of at-risk pregnancies), it is anticipated that there should be a reduction in such admissions with better outcomes. Close follow-up of this high-risk group of infants is also important in order to offer early intervention to those who may possibly have perinatally-related developmental difficulties.

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Key words: Characteristics, Follow-up, Intervention, Predictors of mortality, Outcome

Introduction

With the rapid advances in the field of neonatal intensive care, the focus of interest has been on the very-low-birth-weight (VLBW) infant in recent years. The outcome of these infants has been extensively studied and widely reported. On the other hand, data on the incidence, risk prediction and outcome of normal-birth-weight (NBW) infants requiring neonatal intensive care support are scarce.

Most studies involving full-term or NBW neonatal intensive care unit (NICU) infants were carried out and reported more than 5 years ago. In 1989, Ludman et al¹ reported on the factors associated with the developmental progress of full-term neonates requiring intensive care. Szász et al² reported a 5-year study on the mortality among mature neonates requiring intensive care. Philips and co-

workers³ were one of the first groups to study the characteristics, mortality and outcome of infants weighing at least 2500 g. Their data, however, were collected from infants born in the late 1970s. Richardson, Gray and their other co-workers⁴⁻⁷ have done significant work in the area of neonatal intensive care. In one of their more recent studies in 1996, Gray et al⁴ looked at the health outcomes and costs involved for NBW intensive care unit survivors, concentrating mainly on the hospital charges and readmission factors.

In an attempt to assess risk predictors of newborn mortality, Lindeke et al⁸ reported that birth weight was an independent predictor of neonatal mortality. Locally, there are no reports on NICU NBW infants and data available cannot be extrapolated to our local cohort. Hence, this

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retrospective study was done to describe the characteristics of NICU NBW infants and to document the immediate and short-term outcome as well as to evaluate factors predictive of mortality in these infants.

Material and Methods

Patient Selection

NBW neonates were defined as infants with a birth weight of more than or equal to 2500 g. Patients who satisfied this criterion and who were admitted to the NICU of Singapore General Hospital (SGH) from January 1991 to December 1992 were identified for inclusion in the study. The SGH is a tertiary care teaching institution providing care for women with normal as well as high-risk pregnancies. The NICU of the SGH is an 8-bedded level III NICU, then staffed by 3 specialists, 2 fellows and 4 resident doctors on a 24-hour basis.

In-born patients, who develop respiratory distress, require continuous cardiovascular monitoring or parenteral nutrition, are admitted to the NICU. Neonates requiring general surgical, neurosurgical or cardiovascular procedures are also managed in the NICU after the operative procedures if tertiary care is deemed necessary. Transfer to the paediatric surgical unit may be effected upon the surgeon's request, especially in cases where surgical concerns persisted. The respiratory data and intervention provided for such cases would then be only studied up to the time of transfer. The unit also admits out-born infants from other level II or level III nurseries for purpose of tertiary care. Patient transport is effected by the individual hospital of transfer and patients are usually accompanied by trained medical staff.

Data Collection

The unit keeps a logbook of all patients admitted to the NICU. The names of the patients who satisfied the birth weight admission criteria were collected. The socio-demographic characteristics, modes of delivery and Apgar scores were obtained from the perinatal forms.

The medical records were retrospectively reviewed to obtain data on the diagnoses, clinical presentation of illness, the intervention given in terms of respiratory care and procedures, complications of illness and outcome. The following is a list of the definitions of terminology and abbreviations as used for the purpose of this study.

Hyaline membrane disease (HMD): Respiratory distress due to surfactant deficiency and lung immaturity; chest radiographs shows bilateral reticulogranular appearance with/without air bronchogram.

Transient tachypnoea of the newborn (TTNB): Self-limiting respiratory distress usually of less than 24 hours' duration associated with chest radiographs which are normal/show minimal interstitial fluid.

Pneumonia: Respiratory distress associated with patchy infiltrates on chest radiographs, not associated with meconium-stained amniotic fluid.

Meconium aspiration syndrome (MAS): Presence of respiratory distress associated with the presence of meconium-stained amniotic fluid and chest radiographs exhibiting bilateral patchy infiltrates consistent with aspiration.

Persistent pulmonary hypertension of newborn (PPHN): Respiratory distress associated with clinical evidence of pre- and post-ductal shunting and persistence of high pulmonary pressures, right-to-left shunting and normal structural heart confirmed by 2D echocardiography.

Congenital diaphragmatic hernia (CDH): Herniation of abdominal contents into the thoracic cavity through a defect in the diaphragm, confirmed by chest radiograph and 2D echocardiography, usually associated with respiratory distress.

Congenital heart disease (CHD): Evidence of a structural cardiac defect on 2D echocardiography.

Hypoxic ischaemic encephalopathy (HIE): Asphyxia neonatorum, defined for purpose of this study as a 5-minute Apgar score of less than 8 and significant metabolic acidosis requiring correction (associated with a base excess of more than minus 10 in this practice), with occurrence of seizures being deemed as with worse prognosis.

Sepsis: Blood/cerebrospinal fluid collected within 72 hours of life being positive on bacterial culture.

Patients were categorised according to the system involved in the main disease process. Intervention provided during the NICU stay was also evaluated. Active intensive care treatment was defined by the need for respiratory support, either in the form of hood oxygen, continuous positive airway pressure or mechanical ventilation. All infants received continuous monitoring for heart rate, respiratory rate, oxygen saturation and for the ventilated infants, ventilator settings, which included inspired oxygen (FiO_2), peak inspiratory pressure (PIP) and airway pressure (MAP), rate and inspiratory time. The nurses recorded all these variables on an hourly basis on the respiratory chart of each individual patient, as well as at any instance that ventilator settings were changed. Arterial blood gases performed for each infant were also charted serially. The severity of illness was determined by the mean FiO_2 , mean PIP and mean MAP needed to maintain good oxygenation over the first 3 days of ventilation, as well as the mean AaDO_2 on the first day of ventilation.

Mortality was defined as death occurring prior to discharge or transfer from the Department of Neonatology. The duration of NICU as well as hospital stays were recorded and the discharge destinations noted. The follow-up care of

each patient was also recorded, up to 2 years of age. The follow-up parameters studied included growth measurements (weight, height and head circumference), neurological findings, need for visual or hearing aids and use of intervention services such as physiotherapy, occupational therapy and speech and language therapy. Normality was defined as the child being healthy at the time of last follow-up, with growth parameters within normal limits (between 3rd and 97th percentiles), normal neurological examination with age-appropriate developmental milestones and not requiring any early intervention, hearing or visual aids.

Statistical Analysis

Data on patient demographics and measurements were analysed using SPSS version 7.0 statistical package.

The diagnoses of this group of patients were analysed as well as the intervention that was required. The mean FiO_2 , PIP and MAP over the first 3 days of ventilation were calculated using the hourly values recorded on the respiratory care charts. The airway-alveolar oxygen gradient (AaDO_2) for each set of blood gas was calculated and the mean of all AaDO_2 values for all arterial blood gases done over the first day of ventilation was then computed. Bivariate analysis comparing these respiratory data between the ventilated survivors and non-survivors was done using the Mann-Whitney U test. A *P* value of less than 0.05 was considered significant. The causes of mortality were studied. Logistic regression was then performed to determine factors contributing to mortality. Factors studied included the male sex, the presence of main diagnostic groups (respiratory disorders, cardiovascular disorders, gastrointestinal disorders, neurological disorders, malformations, structural or musculoskeletal defects, chromosomal disorders, metabolic disorders, sepsis and trauma) as well as mean respiratory parameters (fraction of inspired oxygen, peak inspiratory pressure, mean airway pressure and airway-alveolar oxygen gradient). Birth weight and gestation were not included in this part of the analysis as the study group was a defined group.

Results

Patient Characteristics

During the 2-year study period, there were 8510 live births at the Singapore General Hospital. Of these, 7819 were NBW infants, comprising 92% of all live births. One hundred and fifty-four of the NBW infants (comprising 2.0% of all NBW infants) required admission to the NICU during the study period, contributing to 1.8% of live births and 41% of all NICU admissions. Complete data were available for 137 infants.

The mean birth weight of the study population was 3243

± 486 (range, 2530 to 4660) g. The mean gestation was 39 ± 2 completed (range, 32 to 42) weeks. Thirteen infants were premature (gestation less than 37 weeks). Only 1 infant was post-term. The pattern of racial distribution (Chinese, 54.7%; Malay, 37.2%; Indian, 5.8%; and others, 2.2%) was similar to that of the national racial distribution⁹ in 1991-1992 (Chinese, 68%; Malay, 20%; Indian, 8%; and others, 4%), although the proportion of Malays in this study population was noted to be slightly higher. The study population had a slight preponderance of males (males, 55.5%; females, 44.5%). Forty-six per cent were delivered by normal vaginal delivery, 2.2% were assisted breech deliveries, 19.7% required assisted delivery by vacuum or forceps and 32.1% were delivered by Caesarean section. The mean Apgar scores $\pm$ SD at 1 and 5 minutes were 6 $\pm$ 2 and 8 $\pm$ 2, respectively. Thirty-six infants had Apgar scores of less than 8 at 5 minutes of life.

Primary Diagnoses

Even without including respiratory malformations, a respiratory disorder was the main cause for NICU admission in about two-thirds of the study population (Table I). Almost half of these were due to pneumonia and just over a quarter were due to MAS. Among infants with pneumonia, only 1 infant had a positive blood culture.

Congenital malformations comprised 14.6% of all NBW NICU admissions. CDH was the most commonly occurring malformation (6.6%) requiring NICU care. The next most common malformation was CHD (5.1%).

Almost 7% of all admissions were secondary to cardiac disorders with 5.1% having congenital structural anomaly.

Although a quarter of NBW NICU admissions had some form of neurological disorder, only 13.1% had it as the primary diagnosis. Almost all of these (11.7%) comprised infants with HIE as the primary diagnosis. Two infants (1.5%) had seizures secondary to hypocalcaemia.

The other main diagnoses included gastrointestinal diseases (3.6%), chromosomal anomaly (0.7%), trauma (2.2%) and septicaemia (1.5%).

Among the premature infants, 8 out of 13 had a respiratory disorder as the main diagnosis. Of these 8, half had HMD; 2 had pneumonia and 2 had TTNB. There were 2 infants with malformations: 1 with CDH and 1 with multicystic kidney. There was one each of supraventricular tachycardia, sepsis and perinatal stress.

Intervention in the NICU

One hundred and twelve infants (81.8%) required respiratory support to maintain oxygenation; 27.8% requiring mechanical ventilation and 54% requiring only hood oxygen (Table II). A total of 115 episodes of umbilical catheterisation were performed among the 137 infants. Three-

TABLE I: MAIN DIAGNOSES OF NORMAL-BIRTH-WEIGHT INFANTS ADMITTED TO THE NICU (REASONS FOR ADMISSION)

Type of disorder	No.	% of whole cohort	Comments
Respiratory disorder*	84	61.3	
TTNB	9	6.6	
MAS	24	17.5	1 infant also has HIE‡
HMD	8	5.8	
Pneumonia	38	27.7	
Airleak	1	0.7	
1° PPHN	1	0.7	
Others	3	2.2	2 respiratory depressions, 1 stridor
Cardiovascular disorder*	2	1.5	1 supraventricular tachycardia, 1 CCF
Gastrointestinal disorder*	3	2.2	omphalocele, preNEC, mesenteric liver tumour
Neurological disorder*	18	13.1	
HIE	16	11.7	1 infant also has MAS‡
Non-HIE seizures	2	1.5	secondary to hypocalcemia
Malformations†	20	14.6	
Respiratory (CDH)	9	6.6	
Cardiac (CHD)	7	5.1	5 complex CHD#, coarctation of aorta/large patent ductus arteriosus, anomalous origin of right pulmonary artery
Gastrointestinal	2	1.5	malrotation, choledochotracheal fistula
Renal	1	0.7	multicystic kidney
Multiple	1	0.7	
Chromosomal anomaly	1	0.7	Patau's syndrome
Trauma	3	2.2	1 skull fracture, 2 subaponeurotic haematoma
Sepsis	2	1.5	
Others	5	3.6	

* Excluding malformations.

Including malformations, the following figures apply: respiratory disorders (67.8%), cardiac disorders (6.6%) and gastrointestinal disorders (3.6%).

† Excludes the infant with chromosomal anomaly.

‡ Due to this infant with both HIE and MAS, the number of infants in the above Table is 138 (100.7%). Denominator remains 137 (100%).

1) Double outlet right ventricle/ventricular septal defect/pulmonary atresia/patent ductus arteriosus;

2) Ventricular septal defect/patent ductus arteriosus/atrial septal defect/hypoplastic right ventricle/interrupted aorta;

3) Transposition of great arteries (intact septum);

4) Fallot's tetralogy;

5) Ventricular septal defect/pulmonary valvular stenosis/patent ductus arteriosus.

CCF: congestive cardiac failure; CDH: congenital diaphragmatic hernia; CHD: congenital heart disease; HIE: hypoxic ischaemic encephalopathy;

NEC: necrotising enterocolitis; MAS: meconium aspiration syndrome; NICU: neonatal intensive care unit; PPHN: persistent pulmonary hypertension of the newborn; TTNB: transient tachypnoea of the newborn

quarters of these were umbilical arterial catheterisation (for monitoring of blood pressure as well as to facilitate blood gas sampling) and a quarter was umbilical venous catheterisation (for infusion of either inotropes or hypertonic solutions to maintain normoglycaemia). Looking at the whole cohort, 65% received umbilical arterial catheter insertion while 19% had umbilical venous catheterisation. Fifty-seven infants (41.6%) received sodium bicarbonate therapy in the NICU for treatment of metabolic acidosis. Some infants might also have earlier received sodium bicarbonate as part of the resuscitation process in the delivery room. These data were, however, not available. Volume expansion with normal saline or fresh frozen plasma was needed in 12.4% of admissions, half of whom (6.6%) needed further vasopressor support (Table II).

Amongst the 25 infants who did not require respiratory intervention, 10 infants had a respiratory disorder (7 pneumonia, 1 TTNB, 2 respiratory depression), 5 infants had a cardiac disorder (4 CHD of whom 3 needed diuretics and 1 died, 1 SVT), 3 infants had a gastrointestinal problem (1 mesenteric tumour of the liver, 1 pre-necrotising enterocolitis, 1 omphalocele), 2 infants had HIE, 2 infants had seizures (secondary to hypocalcaemia) requiring anti-convulsants, 1 infant had a multicystic kidney and 2 infants had miscellaneous disorders (1 perinatal stress—low Apgar scores without HIE, 1 severe hypothermia). Three of these infants required volume support: 1 infant who had post-cardiac-catheterisation femoral thrombosis, 1 infant who had gastrointestinal bleed secondary to pre-necrotising enterocolitis (requiring long line insertion) and 1 infant

TABLE II: INTERVENTION AND PROCEDURES

Type of intervention/procedure	No.	% of whole cohort
Respiratory care	112	81.8
Hood oxygen only	74	54.0
Mechanical ventilation	38	27.8
Lines*		
UAC	89	65.0
UVC	26	19.0
LL	5	3.6
IA line	13	9.5
Volume support*	36	26.3
Normal saline infusion	1	0.7
FFP infusion	16	11.7
Blood transfusion	28	20.4
Platelet transfusion	2	1.5
Inotropic support	9	6.6
Chest tube insertion	4	2.9
Surgery	9	6.6
Exchange transfusion	5	3.6
Use of diuretics	8	5.8
Use of anticonvulsants	14	10.2
Use of bicarbonate for metabolic acidosis	57	41.6

* Figures do not add up to 100% in each subgroup as the procedures performed or intervention required are not mutually exclusive

FFP: fresh frozen plasma; IA: intra-arterial; LL: long line;

UAC: umbilical arterial catheter; UVC: umbilical venous catheter

who had hypotension associated with pneumonia. Of the 7 infants with a diagnosis of pneumonia, 4 received sodium bicarbonate; of these, 1 needed umbilical arterial catheterisation and 1 had hypotension requiring blood product support and inotropes.

Ventilatory Support

A total of 38 infants were mechanically ventilated. Of these, 14 died. The mean duration of mechanical ventilation among the survivors was 5.2 ± 3.0 days. Complete respiratory data were available for 35 infants (13 deaths, 22 survivors). Among ventilated infants, the respiratory parameters in the first 3 days of ventilation included median of the mean FiO_2 of 0.53 (range, 0.22 to 1.0),

median of the mean PIP of 25 (range, 14 to 50) cmH_2O , median of the mean MAP of 12 (range, 2 to 24) cmH_2O with the median of the mean AaDO₂ gradient of 255 (range, 34 to 669) mmHg on the first day of ventilation.

In comparison of respiratory data at the onset of mechanical ventilation (first 3 days) between survivors and deaths, the medians of the mean FiO_2 , PIP and MAP (over the first 3 days of ventilation) as well as the AaDO₂ gradient (over the first day of ventilation) were found to be significantly different (Table III). The median of mean FiO_2 was 0.43 (range, 0.22 to 0.75) for the ventilated survivors versus 0.99 (range, 0.33 to 1.0) for the non-survivors ($P < 0.0005$). The median of the mean PIP was 23 (range, 14 to 34) cmH_2O for the survivors and 34 (range, 17 to 50) cmH_2O for the non-survivors ($P = 0.018$). The median of the mean MAP was 12 (range, 2 to 20) cmH_2O for the survivors and 14 (range, 5 to 24) cmH_2O for the non-survivors ($P = 0.024$). The median of the mean AaDO₂ was 192 (range, 34 to 428) mmHg and 456 (range, 142 to 669) mmHg for survivors and non-survivors, respectively ($P < 0.0005$). Using logistic regression, the only significant factor predicting mortality among the ventilated infants was the mean FiO_2 needed to ventilate the infant and maintain oxygenation (OR, 1.078; 95% CI, 1.030–1.128) at $P = 0.001$.

Outcome during Hospitalisation

Sixteen infants died during the primary hospitalisation resulting in a mortality rate of 11.7%. Congenital anomalies accounted for 43.75% of deaths. Of these, 3 infants had congenital heart disease and 4 infants had congenital diaphragmatic hernia. Asphyxia neonatorum accounted for 31.25% of deaths, while 2 infants (12.5%) died from pulmonary failure secondary to meconium aspiration syndrome. One infant (6.25%) who died had Trisomy 13 and 1 infant (6.25%) had a skull fracture with intracranial haemorrhage. The median time of death was 2.5 days of life. Logistic regression performed on the main systems involved in the major diagnoses did not reveal any significant contribution towards mortality. One infant, with congenital diaphragmatic hernia, passed away the day after discharge. Her parents had discharged her against medical advice. Seven neonates were transferred to surgical units in the

TABLE III: RESPIRATORY DATA FOR INFANTS ON MECHANICAL VENTILATION

Respiratory parameter	Cohort (n = 35)	Survivors (n = 22)	Deaths (n = 13)	P value
Median (range) of mean FiO_2 (%)	53 (0.22, 1.0)	43 (22, 75)	99 (33, 100)	<0.0005
Median (range) of mean PIP (cmH_2O)	25 (14, 50)	23 (14, 34)	34 (17, 50)	0.018
Median of mean MAP (cmH_2O)	12 (2, 49)	12 (2, 20)	14 (5, 24)	0.024
Median of mean AaDO ₂ (mmHg)	255 (34, 669)	192 (34, 428)	456 (142, 669)	<0.0005

same hospital, of whom 3 died (1 congenital diaphragmatic hernia, 1 mesenteric tumour of the liver and 1 malrotation of the gut).

Among the survivors (88.3%), the mean duration of NICU stay $\pm$ SD was 6.2 ± 5.1 (median 4.0) days (range, 1 to 34 days). The mean age at the time of discharge from the hospital ($n = 114$) was 12.2 ± 7.4 (median 11.0) days (range, 4 to 70 days).

Follow-up of Survivors

One hundred and seventeen infants (113 discharges from this study unit, excluding the infant who died after being discharged against medical advice, and 4 discharges from surgical units) were followed-up at the specialist follow-up clinic upon discharge. Forty-two patients (36%) were followed-up for at least 6 months after discharge. Of these patients, 23 (54.8%) were followed-up till at least 24 months of age, with a median follow-up duration of 48 (range, 24 to 94) months. Seven infants (16.7%) were discharged between 6 and 24 months, with a median follow-up duration of 14 (range, 6 to 21 months). There were 13 (28.5%) defaulters, with a median follow-up duration of 11 (range, 6 to 23) months.

Of the 23 patients who were followed-up beyond 24 months, 3 infants had evidence of neurodevelopmental abnormalities at the age of 2 years. One child was subsequently diagnosed with an autistic spectrum disorder; 1 child with Down's syndrome and Fallot's tetralogy, developed acute myelocytic leukaemia at 17 months; and the third child, with a history of mild perinatal asphyxia, had global developmental delay. All 3 patients were referred for early intervention and rehabilitation. Neurodevelopmental assessment and developmental history were unremarkable for the other 39 patients, with at least 6 months' follow-up, at the last follow-up visit prior to or at 2 years.

Of the 117 infants who were discharged, there were 10 infants (8.5%) who had no evidence of a follow-up appointment.

Discussion

In this study, we have looked at NICU admissions among NBW infants over a 2-year period prior to the introduction of nasal continuous positive airway pressure (CPAP) in the respiratory management of intensive care infants. NBW infants comprised almost half of all NICU admissions. At 41%, this is similar to the figure reported in the study by Philips et al³ as well as Kulkarni et al,¹⁰ but higher than the 35.4% reported by Gray et al.⁴ Our mortality rate of almost 12% among these NBW infants was much higher than the 2% reported by Gray et al.⁴ The difference in mortality rates reported is possibly due to the high number of transfers to

other subspecialty units or level III nurseries in their study and difference in admission policies of the different NICUs. Gray et al⁴ observed that a large number of the infants in their study were admitted for monitoring and observation, with no intervention required. This would imply that their cohort comprised a smaller proportion of critically ill infants, hence resulting in a much lower mortality rate. Other authors such as Kulkarni et al¹⁰ reported neonatal mortality rate of 12%. These figures certainly confirm the fact that there is a large load of NBW infants requiring intensive care in the newborn period, a finding that definitely has an impact on health costs.

The main reason for admission to the NICU among these infants was a respiratory disorder. This is consistent with the fact that 81.8% of all admissions in our study required some form of respiratory support. In the study by Gray et al,⁴ respiratory support was also the most frequent type of intervention provided for these infants. They reported a rate of only 58.6% of cases requiring active NICU therapy. It must be noted, however, that this figure only reflects therapy on admission day. As mentioned earlier, they concluded that a large number of their admissions were mainly for monitoring and observation, a finding not borne out in our study. Most of our NBW NICU admissions were necessary for optimisation of care of these infants and hence, proper utilisation of available resources. This further emphasised the fact that NBW infants contribute significantly to the use of NICU resources. Hence, it would be necessary to continue to monitor such admissions to the NICU and target improvements in the care of this group of infants.

Looking at the ventilatory requirements among mechanically-ventilated infants, the median of the mean FiO_2 and PIP required were significantly different between survivors and deaths. However, the mean FiO_2 was the only factor predictive of mortality. Having a higher mean FiO_2 over the first 3 days of ventilation puts one at higher risk of adverse outcome. It has been observed that since the implementation of nasal CPAP therapy in 1993, by manipulating the fraction of inspired oxygen, CPAP alone was often sufficient to maintain good oxygenation, reducing the need for mechanical ventilation. This observation is consistent with the findings that FiO_2 is the only predictor of adverse outcome in this present study.

In our study, among those who died, the majority required ventilation. Only 2 out of 16 infants did not require mechanical ventilation. Both these infants had congenital heart disease. One of them needed hood oxygen support. In reviewing the causes of death, it was noted that the most common cause of death was due to some form of congenital malformation. This is consistent with the studies by Szász et al² and Philips et al³. Six infants died from a respiratory

disorder (4 CHD, 2 MAS), making it the single system most commonly involved among those who died. With improved pre- and antenatal care as well as better perinatal management that have developed over the years, a decrease in the numbers of infants with respiratory disorders as well as those with perinatal asphyxia would be expected. With better antenatal diagnostic techniques, the number of infants delivered with congenital malformations, particularly the lethal ones, would likely decrease. Further studies of similar, more recent NICU cohorts to evaluate such expectations would be interesting.

In looking at the follow-up care of NICU survivors, Philips et al³ reported more than 90% of a large unselected group of NBW NICU infants to be normal on follow-up at 36 months chronological age. Although Ludman et al¹ had earlier reported that the developmental outcome was poorer at 1 year in their patients compared to healthy controls, their study group was small and included a selected group of patients with mainly surgical illnesses. Lindeke et al⁸ found that NBW NICU graduates subsequently consumed more community health resources and required careful follow-up. As ours was a retrospective study, the follow-up data were therefore limited. It would have been ideal to be able to follow-up our whole study cohort through 2 years of age, in order to evaluate the outcome for growth and development, to assess further use of community health resources and the impact on health costs.

In assessing the adequacy of follow-up of these patients, it is interesting to note that there was a significant number of defaulters amongst these sick infants who were admitted to the NICU. Ten infants were also apparently not given an appointment for follow-up upon discharge. This calls for better communication between the health team and the family, especially at the time of discharge. A better recall system, with telephone and letter reminders, needs to be implemented in all high-risk departments, to keep track of families who miss or wilfully default the infants' follow-up appointment. With the subsequent implementation of better communication methods and technology as well as establishment of pre-discharge parental counselling by the nursing staff, it is hoped that this has resulted in a better follow-up system. Whether this is true will be borne out in a study (CPAP era) currently being carried out in the department.

In conclusion, this descriptive study of a tertiary NICU set-up shows that the respiratory status of the newborn determines the level of care required. When infants are ventilated, the fraction of inspired oxygen predicts the risk of mortality. NICU resources should remain reserved for

infants who require them. Infants who only require monitoring and observation are better managed in a level II nursery. This study also highlights the importance of follow-up care in the management of NICU NBW graduates. It is necessary to establish a good tracking system for these high-risk patients to ensure that they receive adequate assessment after discharge. This would allow early intervention for those with abnormal development or poor growth and offer such children the possibility of a better outcome. Further studies could also be carried out to evaluate the long-term developmental outcome of NBW NICU infants to evaluate the existence of minor disabilities in such patients as well as assess the impact of such long-term management and follow-up on health costs.

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