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Effects of Perinatal Factors on the Duration and Cost of Hospitalisation for Preterm Infants in a Neonatal Intensive Care Unit in Istanbul

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Abstract: Long hospitalisation and high hospital charges of premature infants are important concerns for parents and health providers. In this study we determined the length of stay and hospital cost of preterm babies and assessed the predictive value of perinatal factors on the duration and the cost of hospitalisation. We reviewed hospital charges and length of stay for a retrospective cohort of 72 premature infants discharged from the neonatal intensive care unit of Marmara University Hospital between January 1999 and January 2000. The perinatal factors were analysed using forward stepwise multiple linear regression analysis. The median gestational age and birth weight of the study group was 33 (28-37) weeks and 1560 (814-2340) grams respectively. Median length of hospital stay was 19 (4-93) days whereas hospital charges were $ 4345 (750-23217). The hospital cost per day of hospitalisation was $ 250 (57-350). We developed a mathematical model to predict length of stay and hospital charges from perinatal information. The equation predicts length of stay within five days in 91% of the cases and has an R^2 of 0.83. Birth weight and presence of respiratory distress requiring mechanical ventilation and bronchopulmonary dysplasia are the most powerful predictive factors in both the duration of hospital stay and hospital costs. In addition presence of intraventricular haemorrhage (IVH) is also an important factor for determining hospital costs. The equation for hospital charges predicts the costs within $1475 in 92% of the cases and has an R^2 of 0.85. This information is helpful in counselling parents to provide an estimate for the duration and cost of hospitalisation as well as introducing quantitative information for health planning and allocation of resources in the country.

Key Words: Hospital cost, duration of hospitalisation, premature

Introduction

The number of surviving premature infants has increased dramatically due to technological and pharmacological advances in perinatal and neonatal care. However the provision of neonatal care in intensive care units remains costly, not only in terms of money and consumption of medical resources but also in terms of parents coping with prolonged separation during hospitalisation. In this study, we determined the length of stay and hospital costs of preterm babies and constructed a statistical model to predict a premature newborn's length of stay in the intensive care unit and hospital charges by using perinatal information.

Materials and Methods

Medical records of preterm infants discharged after staying at least 3 days in the neonatal intensive care unit (NICU) of Marmara University Hospital between January 1999 and January 2000 were reviewed retrospectively. Neonates included in the study met the following criteria: gestational age ≤ 37 weeks, no major congenital anomalies and discharge after staying at least 3 days. Gestational age was determined by a combination of maternal dates and clinical assessment of the baby by Ballard's method. Maternal dates were accepted for gestational age assessment if there was disagreement of more than 1 week with that of Ballard's test. Perinatal asphyxia was defined as a 5th minute Apgar score of less than 3 and the presence of metabolic or mixed acidosis in cord blood gas analysis. Respiratory difficulty starting within several hours after birth with characteristic chest X-ray findings was regarded as respiratory distress syndrome (RDS). Bronchopulmonary dysplasia (BPD) was defined as oxygen requirement at the 36th postconceptional week. The need for mechanical ventilation (MV) was determined in a patient with respiratory distress of any cause when arterial pCO_2>60 mmHg and pO_2<45 mmHg while receiving 100% O_2. Hypoglycaemia, hypocalcaemia, etc., are metabolic problems. Neonatal infection was defined as any bacterial or fungal growth obtained in cultures from sterile body sites. Feeding intolerance was defined as the presence of gastric residuals of more than 30% of the total formula or human milk given at the last feeding, or when the gastric aspirate is bilious. Birth weight, gestational age, sex, presence of RDS, BPD, IVH, infection, feeding intolerance or metabolic problems or need for mechanical ventilation were analysed by forward stepwise linear regression analysis to assess the relative importance of perinatal factors on the duration and cost of hospitalisation.

The cost related data was obtained from the Accounting Department of the hospital and included all physician and nursing services, laboratory and radiology tests and medical supplies. The hospital cost of each infant was calculated in Turkish liras first and then converted to US dollars according to the daily values.

Patients were discharged from the hospital when neonatologists were convinced that they were 1) clinically stable 2) free of apnea and bradycardia 3) able to maintain normal body temperature in an open crib 4) able to gain weight with nipple feedings 5) had adequate parental support

Statistical analysis: Kruskal Wallis one way ANOVA was used to compare the median length of stay, hospital charges and cost per day according to birth weight group since variances were not homogeneous and the data did not follow Gaussian distribution. First of all, logarithmic transformation was done to get Gaussian distribution. Two separate multiple stepwise forward linear regression analyses were used to predict the relationship between length of stay, hospital charges and the infants' characteristics. SPSS for Windows statistical software was used for analysis. Forward selection began with the variable which had the highest correlation with the response variable (length of hospitalisation and hospital charge). The next variable considered for the regression equation was the one that increased R^2 by the greatest amount. If the increase in R^2 was statistically significant according to the F test, it was included in the regression equation. This step by step procedure continued until there were no remaining variable that produced a significant increase in R^2. The values for the regression coefficients were calculated and the regression equation resulting from this forward selection procedure was used to predict outcomes.

Results

Seventy-two preterm infants were included in the study. The median birth weight was 1560 (814-2340) grams and discharge weight was 1782 (1560-2210) grams. Thirty-seven percent of the infants were small for gestational age. The gestational age at birth was 33 (28-37) weeks and postconceptional age at discharge was 36 (33.5-42) weeks. The duration of stay was 19 (4-93) days and the hospital cost per infant was $ 4345 (750-23215) (Table 1).

Table 2 shows the median duration of stay and hospital costs of babies at different birth weight groups. For babies weighing less than 1000 grams at birth, the median stay was 60 (48-93) days and the hospital costs were $ 11430 (7035-23215), which was significantly different from the other groups (p<0.01). Birth weight (BW), presence of bronchopulmonary dysplasia (BPD), intraventricular haemorrhage (IVH) or respiratory distress requiring mechanical ventilation (MV) are the perinatal factors that closely predict hospital costs (Table 3). We developed a mathematical model to predict hospital costs:

Hospital charges = 9464.87 – 3.87 (BW) + 14810.3 (BPD) + 2352.99 (MV) + 5232.95 (IVH)

If BPD or IVH is present or there is need for mechanical ventilation then the constants must be multiplied by 1. In addition, birth weight must be in grams in the equation. The equation predicts hospital charges within $ 1475 in 92% of the cases and has an R^2 of 0.85.

Table 1. Patient characteristics (n=72).

	Median	(minimum-maximum)
*Gestational age (weeks)	33	(28-37)
*Birth weight (g)	1560	(814-2340)
*Discharge weight (g)	1782	(1560-2210)
*Postconceptional age at discharge (weeks)	36	(33.5-42.0)
*Length of hospital stay (days)	19	(4-93)
*Hospital charges (dollars)	4345	(750-23215)

Table 2. Median duration of stay and hospital charges in different birth weight groups.

Birth weight(g)	No. of babies	Length of stay*	Hospital charges**	Cost/day***
<1000	8	60 (48-93)	11430 (7035-23215)	188 (146-250)
1001-1500	24	26 (10-53)	4710 (2750-12500)	206 (57-278)
1501-2000	30	12 (4-28)	3262 (750-8000)	274 (161-667)
2001-2500	10	8 (5-20)	2695 (2395-2800)	337 (300-350)

The groups were compared by Kruskal Wallis one way ANOVA
*p<0.005 ,**p<0.001 , ***p<0.01

Table 3. Analysis of factors in relation to hospital charge.*

	Coefficient of determination (R^2)	p value
Bronchopulmonary dysplasia	53.3	p<0.0001
Birth weight	73.3	p<0.0001
Mechanical ventilation	81.2	p<0.0001
Intraventricular haemorrhage	85.3	p<0.0001

* Birth weight, gestational age, sex, presence of perinatal asphyxia, RDS, BPD, IVH, infection, feeding intolerance or metabolic problems or need for mechanical ventilation were analysed. R^2 and p values were found by using stepwise multiple linear regression analysis.

Table 4. Analysis of factors in relation to duration of stay.*

	Coefficient of determination (R^2)	p value
Birth weight	66.7	p<0.0001
Mechanical ventilation	77.7	p<0.0001
Bronchopulmonary dysplasia	83.5	p<0.0001

* Birth weight, gestational age, sex, presence of perinatal asphyxia, RDS, BPD, IVH, infection, feeding intolerance or metabolic problems or need for mechanical ventilation were analysed. R^2 and p values were found by using stepwise multiple linear regression analysis.

Table 4 shows the factors that are strongly predictive of duration of hospitalisation. Birth weight was the most significant factor. Other factors were the presence of respiratory distress requiring mechanical ventilation and BPD. The equation to predict length of stay (LOS) is as follows:

LOS =65.41 - 0.030 (BW) + 22.74 (BPD) + 11.34 (MV)

The equation predicts length of stay within 5 days in 91% of cases and has an R^2 of 0.83.

Discussion

Long hospitalisation and high hospital charges of premature infants are important concerns for parents and health providers universally but especially in developing countries. Discharging babies according to a functional discharging policy rather than waiting for an arbitrary weight to be reached can substantially decrease the duration and cost of hospitalization (1). Postconceptional age and weight at discharge has ranges of 36-40 weeks and 2010-2620 grams in several studies (2). Brooten et al. have reported that discharging infants after functional maturation (as written above) instead of waiting for a weight of 2200 grams had decreased hospital costs by 27% (3). In our study, the median postconceptional age and discharge weight were 36 weeks and 1782 grams respectively. We accepted the suggested discharge criteria for high risk infants, which include a physiologically stable infant capable of maintaining normal body temperature in an open crib and gaining weight with nipple feedings (4).

We found that the median duration of stay and hospital costs of infants at different birth weight groups were significantly different. In fact, in our study, the most powerful predictive factors of length of stay were birth weight, presence of respiratory distress, requiring mechanical ventilation, and bronchopulmonary dysplasia. Powell et al. have found gestational age at birth, respiratory difficulties, birth weight, infections and metabolic problems to be predictive factors of time of discharge (5). In our opinion, the higher percentage of infants small for gestational age in our patient population made the birthweight the most powerful predictive factor of length of stay. We developed a mathematical model to predict length of stay which predicted the hospital stay within 5 days in 91% of cases and has an R^2 of 0.83. Jijon et al. have reported that gestational age is the most significant predictor of length of stay and have noted that length of stay decreases exponentially with each week of gestational age (6).

Several investigators have performed economic evaluations of neonatal care (6-10). The improvements in outcomes of premature infants have come at no small financial cost.In our study the cost per day of hospitalisation of a premature infant was $250 (57-350), which is much lower than what is reported from a neonatal intensive care unit (NICU) of the USA. ($2006 + 44) (7). The median hospital charges was $4345 for our patient population and was much lower than that of Jijon's report ($26871) (6). The reasons for this difference might be the under payment of health care personnel and lower hospital charges and lower individual income in our country. The income per capita in Turkey is approximately $ 2800/year, whereas it is $ 23000 in the USA. The equation that predicted the hospital charges has an R^2 of 0.85 in our study. Birth weight, presence of bronchopulmonary dysplasia, intraventricular haemorrhage and respiratory distress requiring mechanical ventilation are the factors that closely predict the hospital cost. Jijon et al. reported that gestational age, presence of RDS and pneumonia are the strongest predictors of hospital charges (6).

Costs for the initial hospitalisation presented in this study are an underestimation of true costs for each survivor because NICU graduates require more outpatient care and post NICU hospitalisation. The health related costs for them have been calculated as nine times that for term infants during the first year of life (12,13). Thus the most effective means of decreasing NICU costs is to prevent premature birth. An increase in survival of very low birth weight infants has raised concerns as the cost of caring for such infants and whether or not a disproportionate amount of total health care resources is used on their behalf. However, when health care costs are measured in cost per quality-adjusted life year (QALY) gained, the cost of neonatal care is not expensive (14-16). Tyson et al. have reported that the cost per QALY gained for infants with birth weights of 1000g to 1500g is less than that for treating hypertension in a 40 year old man (17). Comparing the annual direct cost of low birth weight infants to costs of other major health problems, Lewit et al. estimated it to be about one third the annual direct cost of smoking (18).

Additional multicentre outcomes research, adjusted for illness severity, will permit close examination of the variation in and cost effectiveness of individual obstetric and NICU practices. The cost related data are essential for health planning and allocation of resources in developing countries such as Turkey.

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