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Mechanical Ventilation in Neonates: Experience at a Tertiary Care Center in Eastern Nepal

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Authors' contributions

This work was carried out in collaboration between all authors. Authors BKS and GSS were involved in conceptualization, study design, conduction, data analysis and preparation of manuscript. Author OPM was involved in data analysis and drafting the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To study the diagnoses and survival of neonates receiving mechanical ventilation.
Study Design: Prospective observational study.
Place and Duration of Study: Department of Pediatrics and Adolescent Medicine; B. P. Koirala Institute of Health Sciences, Dharan, Nepal, from February 2012 to January 2013.
Methodology: All the neonates who received mechanical ventilation in neonatal intensive care unit (NICU) during the study period were included. We excluded the neonates with surgical malformations. Data were entered in a pre-designed pro forma and statistical analysis was done using SPSS version 17 for Windows.

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Results: A total of 88 neonates were ventilated during the study period of which 65 met the inclusion criteria. Birth asphyxia (34%), neonatal sepsis (31%), meconium aspiration syndrome (MAS) (20%), congenital pneumonia (11%) and hyaline membrane disease (HMD) (5%) were the diagnoses of babies who received mechanical ventilation at our center. Overall survival rate was 50.8%, as 33 patients survived. The highest survival rate was seen in babies admitted with birth asphyxia (68.2%) and the lowest survival rate was seen in neonates with an admission diagnosis of sepsis (30%). Mean Downes score for respiratory distress at intubation in non-survivors was significantly higher compared to Downes score in non-survivors (*P* value = .003). Mean oxygen saturation before intubation in non-survivors was significantly lower than the oxygen saturation in survivors (*P* value = .001).

Conclusion: Birth asphyxia, sepsis and meconium aspiration syndrome were the common diagnoses of neonates who received mechanical ventilation. Neonates with lower Downes score and higher oxygen saturation at the time of admission were associated with decreased mortality rate.

Keywords: Neonates; ventilation; birth asphyxia; NICU; developing country; global health.

1. INTRODUCTION

According to the World Health Organization, nearly three million neonates die every year and most of these deaths (99%) occur in developing countries [1]. Nepal is a resource limited developing country in south-east Asia with neonatal mortality rate of 33 per 1,000 live births [2]. Nearly 20,000 neonates die each year in Nepal, where two thirds of the deliveries take place at home and are not attended by any trained health professional [2]. Many sick neonates die at home or before reaching a tertiary hospital due to lack of supervised transport facility. Causes of neonatal morbidity and mortality in developing countries are different from those in developed ones. Preventable causes of neonatal mortality like infections, meconium aspiration syndrome (MAS) and birth asphyxia are more common in developing countries while prematurity and congenital anomalies are more often involved in developed countries [3].

It has been observed that the "quality of medical care tends to vary inversely with the need for it in the population served" [4]. Strengthening of primary health care is essential to decrease neonatal mortality in resource limited country like Nepal; where most of the babies who die during neonatal period are unnamed and unregistered, resulting in lack of information on neonatal mortality. However, it is equally important to develop infrastructure and train human resources to take care of critically ill patients [5,6]. Neonatal intensive care is a relatively new field in Nepal, and it is still in infancy due to lack of infrastructures, trained health care providers and advanced modalities of treatment like high frequency ventilation, inhaled nitric oxide and extra corporeal membrane oxygenation. There are only few tertiary care centers in Nepal which have facility for providing mechanical ventilation to neonates and most of them are situated in large cities. As there is paucity of published data on this modality of treatment in Nepal, we aimed to study the common diagnoses and survival rate of neonates who received mechanical ventilation over one year period at our center.

2. MATERIALS AND METHODS

B. P. Koirala Institute of Health Sciences (BPKIHS) is the largest tertiary referral center in eastern Nepal with 700 beds. It has a Level II neonatal intensive care unit with 6 intensive care beds, 7 intermediate care beds and 3 Dräger Babylog 8000 plus ventilators. It is equipped with in-house blood gas analyzer, monitors for recording oxygen saturation, heart rate, temperature, non-invasive blood pressure and electrocardiogram, radiant warmers, phototherapy units and facility for exchange transfusion but we do not have facilities for non-invasive CPAP, cranial ultrasonography, bedside echocardiography, total parenteral nutrition and high frequency ventilation. There were 2 pediatric consultants, 5 resident doctors and 14 trained nurses in neonatology unit during the study period. Two residents and five nurses stayed on ward round the clock. The maternity unit of the hospital has a delivery rate of around 9000 per year. All the high risk deliveries in institute are attended by a pediatrician. We have well equipped resuscitation facilities inside the labor room and the obstetric operation theatre where initial steps of resuscitation are provided by the attending pediatrician. Sick neonates are

promptly transferred to the neonatal unit. Outborn neonates arriving at emergency department are usually severely ill. Most of them are brought to the hospital by their parents, and the ambulances used for transportation are rarely accompanied by any health worker. These neonates are initially evaluated and managed by pediatric residents in the emergency department and then admitted to the neonatal unit.

This was a prospective observational study carried out at BPKIHS from February 2012 to January 2013. All the neonates who received mechanical ventilation during the study period were included in study. We excluded the neonates with surgical congenital malformations, neonates ventilated for surgical causes and those who left the hospital against medical advice. Written informed consent was obtained from parents. Baseline characteristics of the ventilated neonates were entered in a pre-designed pro forma which included the place of delivery (inborn/outborn), gender, birth weight, gestational age (according to the date of last menstrual period and/or calculated by the modified Ballard score) [7]. Respiratory distress in the newborn was monitored clinically using Downes score [8]. Oxygen saturation, measured by pulse oxymetry, maximum ventilatory parameters used for each neonate and duration of mechanical ventilation were also entered in the pro forma. Neonates who remained successfully extubated for >48 hours and did not require re-intubation were included in survived group. Those neonates who died during mechanical ventilation or within 48 hours of extubation due to same disease for which they received mechanical ventilation were included in the deceased group.

The following diagnoses were made after reviewing relevant maternal and neonatal history, physical examination and investigations using the standard guidelines [9,10].

Birth asphyxia was diagnosed in outborn babies with slow gasping breathing or no breathing at 1 minute of age and in inborn babies with Apgar score of less than 7 at 1 minute of age. Sepsis was diagnosed in neonates with clinical feature suggestive of sepsis with positive history of risk factors and/or positive septic screen and/or isolation of pathogens from blood or cerebrospinal fluid (CSF) or urine or abscess (es). Meningitis was diagnosed on the basis of CSF microscopy, biochemistry and culture. MAS was defined as respiratory distress in newborns born through meconium stained liquor or staining of nails or umbilical cord or skin with suggestive x- ray findings (atelectasis and/or hyperinflation). Hyaline membrane disease (HMD) was defined as respiratory distress presented within six hours of birth in a premature newborn with characteristic x-ray findings (low volume lungs with air bronchogram/reticulo-granular pattern/ ground glass opacity) and congenital pneumonia presented shortly after birth in neonates with maternal risk factors with suggestive x-ray findings (patchy/streaky infiltrates).

The indications for initiating mechanical ventilation in studied neonates were progressive hypoxemia (PaO_2< 60 mmHg at FiO_2 0.4-0.6 or on oxygen under hood/mask at 6-8 L/min), $PaCO_2$ > 60 mmHg with acidosis (pH <7.2), exhaustion due to increased work of breathing (Downes score > 6) and prolonged/recurrent apneic spells [10].

All the babies were nursed under servo controlled open-care system. The neonates were treated as per standard protocols and relevant investigations were done as required. Ampicillin and Amikacin were the first-line antibiotics used which was later on revised depending upon the culture and sensitivity results. Synchronized Intermittent Mandatory Ventilation (SIMV) mode was used in all neonates with the aim to maintain normal oxygen saturation with normal blood gases with minimal work of breathing at minimum ventilator settings. X-ray chest was taken after initiating ventilation and was repeated according to the need. None of the babies with hyaline membrane disease received surfactant therapy due to its unavailability in local market during the period of study however the mother of intramural neonate did receive antenatal steroid (Inj. Betamethasone, 2 doses 12 hours apart) as per the institutional protocol. Midazolam was used for sedation intermittently during mechanical ventilation.

SSPS (Statistical Packages for the Social Sciences) software version 17 for Windows (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Chi-square test was used for categorical variables and Student's t-test for continuous variables. P<.05 was considered as significant.

3. RESULTS

During the study period, 940 patients were admitted to the neonatal unit of which 88 patients received mechanical ventilation (9.36%). Out of the 88 mechanically ventilated neonates, 20

neonates left the hospital against medical advice, 2 neonates were ventilated for tracheo-esophageal fistula and 1 neonate for diaphragmatic hernia (post operatively). Sixty five neonates met the inclusion criteria out of which 24 (37%) were inborn and 41 (63%) were outborn patients. Overall survival in our study was 50.8%. The baseline characteristics of the study population and of the survived neonates are shown in Table 1. The survival rates in different diagnostic categories are shown in Table 2.

Table 1. Characteristics and survival rate of the studied neonates

Characteristics	No. of babies ventilated n (%)	Survived n (%)
Place of birth		
Inborn	24 (37%)	16 (66.7%)
Outborn	41 (63%)	17 (41.5%)
Gender		
Male	40 (61.5%)	21 (52.5%)
Female	25 (38.5%)	12 (48.5%)
Birth weight		
< 1000g	2 (3.1%)	0 %
1000-1500 g	9 (13.8%)	2 (22.2%)
1501-2000 g	8 (12.3%)	4 (50%)
2001-2500 g	17 (26.2%)	8 (47.1%)
> 2500 g	29 (44.6%)	19 (65.5%)
Gestational age (weeks)	9 (13.8%)	2 (22.2%)
28-32	16 (24.6%)	8 (50%)
33-37	40 (61.5%)	23 (57.5%)
> 37		
Downes score at intubation	17 (26.2%)	12 (70.6%)
≤ 6	48 (73.8%)	21 (43.8%)
≥ 7		
Total	**65 (100%)**	**33 (50.8%)**

Birth asphyxia (34%), sepsis (30.8%), MAS (20%), congenital pneumonia (10.8%) and HMD (4.6%) were the common diagnostic conditions for which babies received mechanical ventilation. Babies ventilated for birth asphyxia had the highest survival rate (68.2%). Three babies with HMD were ventilated; of which only one baby (inborn) survived. Twenty neonates with sepsis were ventilated; 4 inborn and 16 outborn neonates including 7 neonates with meningitis. Only 6 out of them survived.

Table 3 compares between survivors and non-survivors; the mean gestational age and birth weight were 37.57±2.8 weeks and 2662.58±684.77 gram respectively in survivors; and 36.04±3.86 weeks and 2225.00±813.9 gram in non-survivors (*P* values =.07, .22 respectively). Mean Downes score before intubation was significantly higher in survivors compared to non-survivors. (*P* value = .003) Mean oxygen saturation at intubation was significantly lower in non-survivors (*P* value= .001).

Table 2. Survival of ventilated neonates according to diagnosis

Diagnosis		Total n	Survived n (%)
Birth asphyxia	Inborn	9	7 (77.8)
	Outborn	13	8 (61.5)
	Total	22	15 (68.2)
Sepsis	Inborn	4	2 (50)
	Outborn	16	4 (25)
	Total	20	6 (30)
Meconium aspiration syndrome	Inborn	5	3 (60)
	Outborn	8	5 (62.5)
	Total	13	8 (61.5)
Congenital pneumonia	Inborn	5	3 (60)
	Outborn	2	0 (0)
	Total	7	3 (42.8)
Hyaline membrane disease	Inborn	1	1 (100)
	Outborn	2	0 (0)
	Total	3	1 (33.3)
Total		**65**	**33**

Table 1. Comparison between survivors and non-survivors

Parameters	Survivors (Mean ± SD)	Non-survivors (Mean ± SD)	*P* value
Gestation (weeks)	37.57±2.8	36.04±3.86	.07
Birth weight (gram)	2662.58±684.77	2225.00±813.9	.22
Downes score	6.91±1.20	7.84±1.22	.003
SpO_2 before intubation	74.45±9.46	66.38±8.82	.001
FiO_2 (maximum)	90.91±15.88	93.75±13.85	.44
PIP (maximum)	19.27±2.74	19.09±3.10	.80
PEEP (maximum)	4.72±0.71	4.86±0.63	.41
Duration of ventilation (hours)	125.52±52.56	108±53.56	.192

PIP - Peak Inspiratory Pressure, PEEP - Positive End Expiratory Pressure

4. DISCUSSION

Birth asphyxia was the most common cause for mechanical ventilation in our study whereas it was third most common cause for ventilation in previous studies [11,12,13]. Other studies reported preterm-HMD as the commonest diagnosis requiring ventilation [13,14,15]. Although birth asphyxia was the most common diagnosis, this disease does not reflect the most common indication for mechanical ventilation at our center as many patients who required mechanical ventilation could not receive it due to the very limited number of ventilators available.

Overall survival in the current analysis was 50.8%, which is comparable to that reported from other neonatal intensive care units (NICU) in India. Survival outcome in various studies has ranged from 41.2% to 67.9% [12,16,17]. Survival rate was highest in neonates with birth asphyxia (68.2%) in the present study and in a study reported by Karthikeyan and co-workers (79.3%) [16]. Less than 50% survival in asphyxiated babies was reported by other authors [11,18] while 14% survival was observed in series by Singh and co-workers [14]. We observed the survival rate of neonates with congenital pneumonia was 42.8% whereas other authors reported higher survival rates ranging from 66.6% to 100% [12,14,18]. Neonates with MAS had a survival rate of 61.5% in this study whereas MAS had the highest survival in series by Malhotra et al. [12] and Riyas et al. [11], with 100% and 63.6% survival rates respectively. Conversely, the highest mortality was seen in the series by Singh et al. [14] and Karthikeyan et al. [16], where all the babies who were ventilated for MAS died. Lower survival rates in neonates with MAS at our center and in the mentioned studies may be attributed to the unavailability of advanced modalities of treatment like inhaled nitric oxide and high frequency ventilation.

Sepsis had the lowest survival rate (30%) in this study. Sepsis had a uniformly low survival rates in all other studies [14,18]. Higher mortality rates in neonatal sepsis may be associated with other factors like temperature instability, shock, dyselectrolytemia and acidosis, where the technique of mechanical ventilation has probably lesser role in determining outcome. This emphasizes the fact that preventive measures like hand washing and infection control supportive care remains cost effective interventions to reduce neonatal mortality in resource limited settings [19]. Also, surfactant should be locally available at reasonable cost to prevent deaths from HMD as none of the neonates with HMD received surfactant at our center, resulting in a survival rate of only 33.3%.

In this study, an increase in birth weight was associated with a better survival which is similar to other studies. [8,12,16,18], Contrary to Mathur et al. [20], who reported that an initial FiO_2 requirement of more than 60% was a significant independent predictor of mortality, we did not find any significant difference in FiO_2 between survivors and non-survivors. However, the severity of respiratory distress as measured by Downes score was significantly higher among the non-survivors (*P* value = .003). Also the mean oxygen saturation at intubation was lower in non-survivors compared to the survivors (*P* value = .001).

5. CONCLUSION

Birth asphyxia, sepsis and meconium aspiration syndrome were the most common diseases for which neonates received mechanical ventilation at our center. Higher Downes score and lower oxygen saturation at the time of admission, both indicating a more severe respiratory failure, were associated with an increased mortality rate.

CONSENT

All authors declare that written informed consent was obtained from the parents of the patients for this study.

ETHICAL CLEARANCE

Ethical clearance was taken from the Institutional Ethical Committee.

COMPETING INTEREST

Authors have declared that no competing interests exist.

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