Original Article

Requiring Mechanical Ventilation in Neonates' Respiratory Distress Syndrome — Short-Term Outcome

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ABSTRACT

Backgrounds*: There has been a significant decline in neonatal mortality in developed countries, largely due to the introduction of mechanical ventilation systems and protocol-based management in neonatal intensive care. However, the fatality rate remains high in developing countries. Therefore, this study was conducted to assess the immediate hospital outcomes of neonates who required mechanical ventilation.* ***Objectives:*** *This study was carried out to see the immediate outcome of neonates who required mechanical ventilation to relate the immediate outcome with diseases for which mechanical ventilation was initiated.* ***Methods & material:*** *This study was conducted in the Neonatal Intensive Care Unit at CMH Dhaka from January 2016 to December 2016. Neonates requiring mechanical ventilation during the study period were prospectively included. Throughout the duration of mechanical ventilation, the neonates were monitored for any complications until discharge or death.* ***Results:*** *A total of 30 neonates were enrolled in the study. Among them, 22 (73.3%) were preterm and 8 (26.7%) were full-term, with 25 (83.3%) having a birth weight of less than 2500 grams. Respiratory Distress Syndrome (RDS) was the most common reason for requiring mechanical ventilation accounting for 11 (36.7%), other indications were Perinatal asphyxia 7 (23.3%), Septicemia 6 (20.0%), Congenital pneumonia 5 (16.7%), and Meconium Aspiration Syndrome (MAS) 1 (3.3%).* ***Conclusions:*** *In this study, the most common causes of Mechanical Ventilation (MV) were Respiratory Distress Syndrome followed by Perinatal asphyxia and Septicemia. Outcome was good in RDS and poor in Septicemia and Perinatal asphyxia.*

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INTRODUCTION

Mechanical ventilation has become an essential component of neonatal intensive care [1]. The introduction of mechanical ventilation was one of the major new inventions in neonatology which provided life-saving support for neonates with respiratory failure [1]. The risk of death during the first month of life 23 per 1000 live births is nearly two and a half times greater than in the subsequent 11months[2]. It is also noteworthy that deaths in the neonatal period account for 62 percent of all fewer than 5 deaths[2]. The neonatal mortality rate over the past five years was 32 deaths per 1,000 live births, which was three times the post-neonatal mortality rate (10 deaths per 1,000 live births)[3]. This finding reflects the misery of neonatal health status in this country. Among all neonatal death 60% occurred in rural Bangladesh[3]. Major causes of neonatal deaths were Perinatal Asphyxia, Septicemia and Low Birth Weight. Community based intervention is essential to reduce the high neonatal mortality rate. But in contrary a few babies need specialized support like neonatal intensive care management which includes surfactant therapy, mechanical ventilation and exchange transfusion for their survival[3].

The application of mechanical ventilation to neonatal respiratory disorders is one of the major breakthroughs in the history of neonatal care[4]. For over 40 years, conventional mechanical ventilation has been utilized in the treatment of neonatal respiratory failure[4]. Neonatal respiratory failure encompasses various disease entities, each with distinct pathophysiological characteristics[4]. A significant number of neonates in the neonatal intensive care unit require mechanical ventilation. Over the past three decades neonatal mortality has fallen steadily. Success of intensive care is usually presented as mortality rate adjusted for severity of illness[5]. These mechanically ventilated neonates have a high fatality[6].

There are various ventilation modes available for newborns. Over the past four decades, the range of mechanical support options for neonatal respiratory failure has expanded significantly[4]. For a quarter of a century, Continuous Positive Airway Pressure (CPAP) and time-cycled, pressure-limited Intermittent Mandatory Ventilation (IMV) were the primary treatment methods. However, technological advances in the 1980s and 1990s introduced High Frequency Ventilation (HFV) and advanced ventilatory techniques into neonatal intensive care[4].

Time-cycled, pressure-limited ventilation (Intermittent Positive Pressure Ventilation, IPPV) is commonly known as conventional ventilation, as it has been the most frequently used mode for newborns [11]. For over two decades, IMV was essentially the sole mode used for newborns[12]. Irrespective of the technique or mode of the ventilation chosen, the goals of mechanical ventilation remain same: (1) to achieve and sustain adequate pulmonary gas exchange (2) minimize the risk of lung injury (3) to decrease the patient's work of breathing (WOB) (4) to enhance patient comfort[13].

The occurrence of one or more of the following conditions constitutes an indication for mechanical ventilation; Respiratory Distress Syndrome (RDS), Severe Perinatal Asphyxia, Repeated Apnea, Meconium Aspiration Syndrome, Pneumonia, Sepsis, Congenital heart disease, Shock[14-16].

The outcome was affected by the gestational age and birth weight of the neonate[21]. Severe Perinatal asphyxia had a high mortality[21]. Weight <2500 gm, gestation <34 weeks, initial arterial pH<7.2, shock, pulmonary hemorrhage, apnea, were significant predictors of mortality in ventilated neonates[21]. Respiratory distress syndrome was among the most prevalent conditions requiring mechanical ventilation[22]. Survival rate was higher in babies requiring mechanical ventilation for respiratory distress syndrome (84.2%)[22].

Outcome was poor in neonates with sepsis[23]. Iqbal Q showed survival rate of 35.3%[23]. Pulmonary hemorrhage was life threatening event in neonates and prognosis was poor[23]. Hossain MM. and Anantharaj A. also observed very unfavorable outcomes in neonates following pulmonary hemorrhage[16,24].

Shock was an important cause of mortality in ventilated neonate[23]. Shock signifies a severe stage of a disease process of varied etiologies and its relationship with mortality was understandable[24]. Acidosis (pH <7.2) at admission also predicted an increased mortality. A lower pH at admission suggests a longer interval between the onset of the events causing the child's clinical deterioration and their arrival at the healthcare facility[23].

In CMH Dhaka neonatal ventilation has been carried out since 1998 in NICU. This study was conducted to assess the immediate outcome of neonates who required mechanical ventilation to relate the immediate outcome with diseases for which ventilation was initiated.

METHODS & MATERIALS

In this cross-sectional prospective study conducted at the Department of Paediatrics, CMH Dhaka, over a period of one year from January 2016 to December 2016, the focus was on neonates admitted to the Neonatal Intensive Care Unit (NICU) and in need of mechanical ventilation. The study aimed to collect comprehensive data through a structured approach, involving history taking encompassing antenatal, natal, and immediate postnatal aspects, physical examinations, and various laboratory investigations, including arterial blood gas (ABG) analysis. The sample size was limited to 30 patients due to time constraints, with inclusion criteria consisting of neonates in NICU requiring mechanical ventilation. Exclusion criteria were neonates with congenital anomalies incompatible with life that necessitated mechanical ventilation. The operational definitions clarified terms such as neonates, mechanical ventilator, low birth weight, very low birth weight, and extreme low birth weight. Essential equipment, including ABG analysis tools, chest X-ray machines, ventilators, and pulse oximeters, were employed throughout the study. The main outcome variables included socio-demographic factors, age, gender, mode of delivery, weight, APGAR score, oxygen requirements, indications for mechanical ventilation, ABG parameters, and mortality. Various laboratory tests, such as complete blood count, C-reactive protein, blood culture and sensitivity, serum electrolyte, and serum creatinine, were

performed and recorded.

Data were collected using a specially designed questionnaire and subsequently analyzed using SPSS Version 19.0. The study emphasized voluntary participation, with written informed consent obtained in Bengali, ensuring confidentiality and the right to withdraw at any point. Interviews were conducted at suitable times and locations convenient for the participants, prioritizing ethical considerations throughout the research process.

RESULTS

This cross-sectional study was conducted in CMH, Dhaka to find out the immediate outcomes of mechanically ventilated neonates. The study included 30 ventilated neonates. Mean age at onset of mechanical ventilation was 2.9 ± 5.23 days and mean duration of mechanical ventilation was 4.1 ± 2.61 days.s. After completion of data collection, all data were compiled, tabulated and then analyzed by SPSS v.19 according to the objectives of the study. The results of the study are as followed:

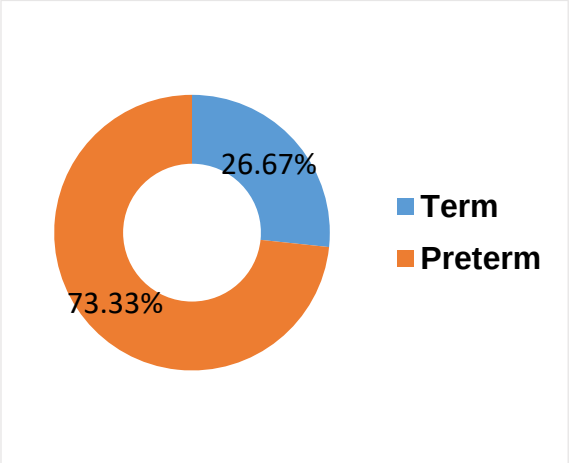

Figure 1: Distribution of neonate by gestational age

Figure 1 showed the distribution of neonate by gestational age. Among 30 neonates 22 (73.3%) were preterm (<37 weeks) and 8 (26.6%) were term (>37 weeks). Mean Gestational age (weeks): 32.59 ± 3.54.

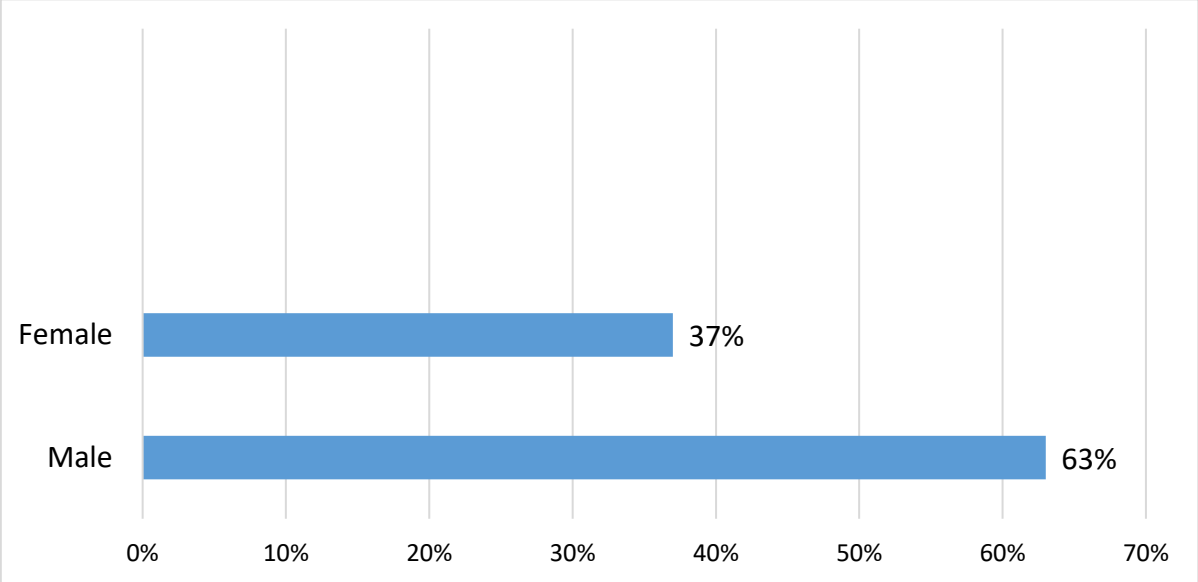

Figure 2: Distribution of neonate by sex

Figure 2 showed the distribution of neonate by sex. Among the neonates 19 (63.3%) male and 11 (36.7%) were female and male to female ratio was 1.7:1.

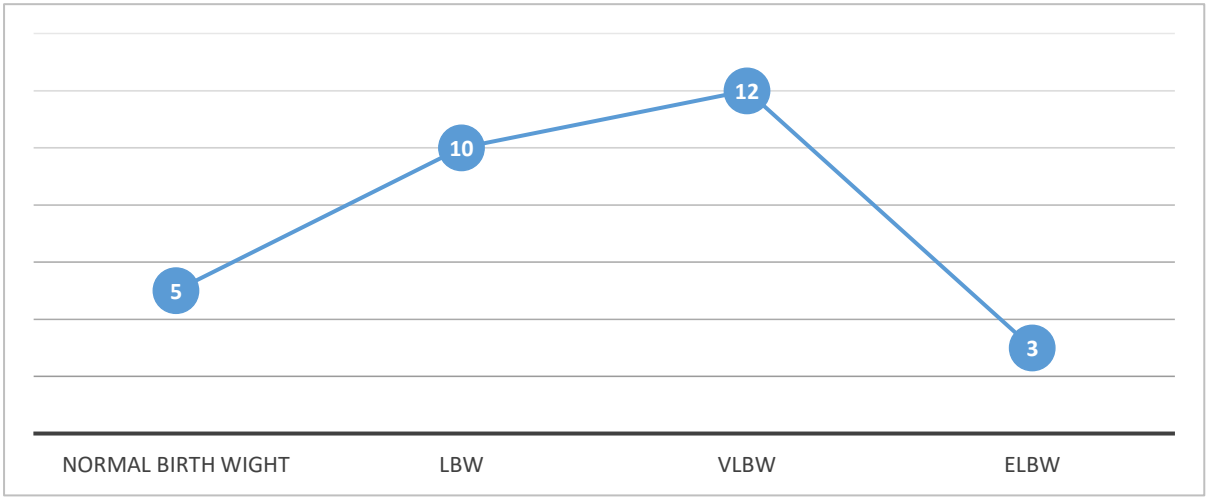

Figure 3: Distribution of neonates by birth weight

Figure 3 showed the distribution of neonates by birth weight. The mean birth weight of the ventilated neonates were 1800 ± 741 gram of which 5 (16.7%) had normal birth weight, 10 (33.3%) had low birth weight, 12 (40.0%) had very low birth weight and 3 (10.0%) neonates had extreme low birth weight.

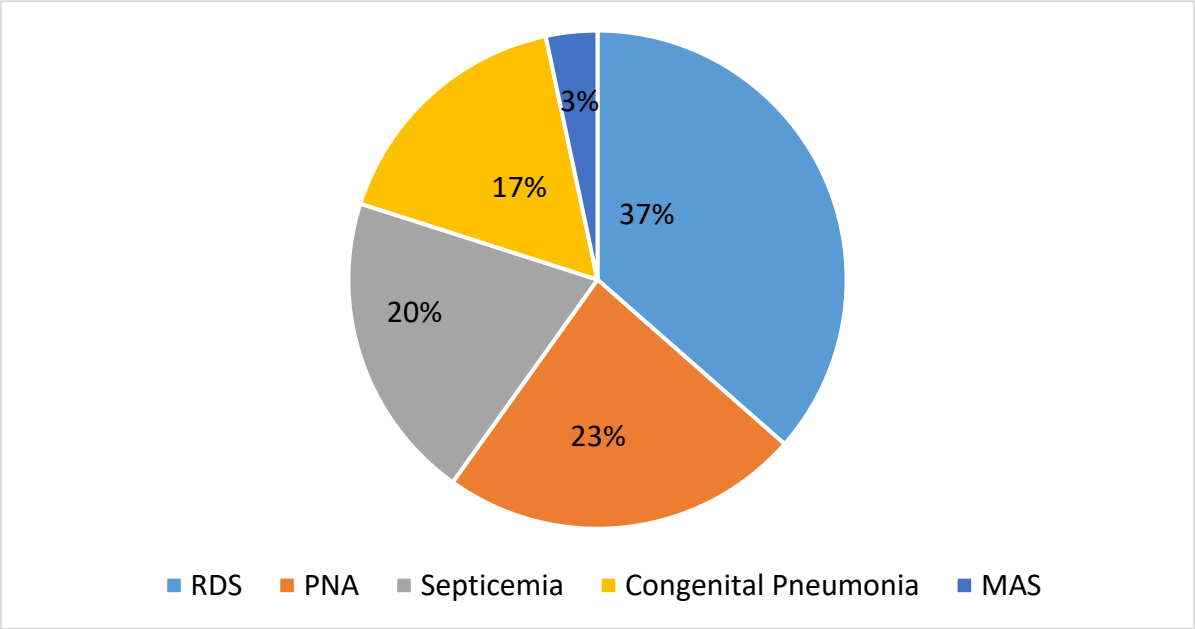

Figure 4: Distribution of neonates by indication of mechanical ventilation

Figure 4 showed the indication of mechanical ventilation. Respiratory Distress Syndrome (RDS) was the commonest indication total in 11 (36.7%) of mechanical ventilatilated babies. The other indications were Perinatal asphyxia 7 (23.3%), Septicemia 6 (20.0%) and Congenital pneumonia 5 (16.7%).

Table I: Distribution of mean arterial blood gas at the time of initiation of Mechanical Ventilation (MV) by indication of MV

Arterial Blood Gas (Mean ± SD)					
Indication of MV	**P^H**	**PCO_2 (mmHg)**	**PO_2 (mmHg)**	**mEq/L**	**HCO_3 BE mmol/L**
RDS	7.26±0.07	52.48±7.77	90±16.60	20.4±4.1	- (3.8±2.1)
PNA	7.19±0.13	67.31±10.3	93±20.23	11.9±5.8	- (11.6±2.4)
Pneumonia	7.31±0.07	53.51±10.8	87±17.67	19.4±2.9	- (4.6±2.4)
Sepsis	7.23±0.13	63.32±14.9	92±21.13	18.0±4.7	- (5.5±2.6)
MAS	7.29±0.00	48±0.00	91±0.00	14.3±0.00	- (8.8±0.00)

Table I showed the distribution of mean arterial blood gas at the time of initiation of Mechanical Ventilation (MV) by indication of MV. In RDS it was, P^H, $PC0_2$, $P0_2$, HCO_3 and BE was 7.26 ± 0.07, 52.48 ± 7.77 mmHg, 90 ± 16.60 mmHg, 20.4 ± 4.1 mEq/L and 3.8 ± 2.1 mEq/L respectively. In PNA, it was 7.19 ± 0.13, 67.31 ± 10.3 mmHg, 93 ± 20.23 mmHg, 11.9 ± 5.8 mEq/L and 11.6 ± 3.1 mEq/L respectively. In case of **Congenital pneumonia** it was 7.31 ± 0.07, 53.51 ± 10.8 mmHg, 87 ± 17.67 mmHg, 19.4 ± 2.9 mEq/L and 4.6 ± 2.4 mEq/L respectively.

Table II: Distribution of initial ventilatory settings at the time of initiation of MV by indication of MV

Indications of MV	**VR (per min)**	***PIP (cm H_20)**	**PEEP (cmH_2O)**	**I:E**	**FiO_2 (%)**
RDS	40	18	5	1:2	70
PNA	40	16	4	1:1.5	90
Pneumonia	40	18	5	1:2	80
Sepsis	30-40	14-16	4-5	1: 2	80-90
MAS	40	18	4	1:3	80

**In case of ELBW babies: 15 cm H_20*

Table II showed the distribution of Initial ventilatory settings at the time of initiation of MV by indication of MV In case of **RDS**, initial settings were VR-40/min, PIP- 18 cm H_20, PEEP- 5 cm H_20, I:E-1:2, $Fi0_2$- 70%. In **PNA**, it was 40/min, 16 cm H_20, 4 cm H_20, 1:1.5, 90%. **Congenital pneumonia** it was 40/min, 18 cm H_20, 5 cm H_20, 1:2, 80% respectively

Table III: Outcome of mechanically ventilated neonate by different attributes

Different Attributes	Death, *n* (%)	Survivor, n (%)
Gestation		
Preterm	11(50.0)	11 (50.0)
Term	02 (25.0)	06 (75.0)
Sex		
Male	08 (42.1)	11 (57.9)
Female	05 (45.5)	06 (54.5)
Birth weight		
>2500 gm	01 (20.0)	04 (80.0)
<2500 gm	12 (48.0)	13 (62.0)
Place of delivery		
Out born	07 (58.3)	5 (41.7)
Inborn	06 (33.3)	12 (66.7)

Table III showed the outcome of mechanically ventilated neonates by gestational age, sex, birth weight and place of delivery. Total 22 patients were preterm and 8 were term. Among them 11(50.0%) and 02 (25.0%) died respectively. Among 19 male neonates 8 (42.1%) died and among 11 female neonates 5 (45.5%) were died. Only 1 (20.0%) of total 5 normal birth weight (>2500gm) baby died, but 12 (48.0%) of 25 low birth weight baby (<2500gm) died.

Table IV: Distribution of outcome of mechanically ventilated neonates by indications of MV

Indication of MV	Death, n (%)	Survivor, n (%)
RDS	05 (45.5)	06 (54.5)
PNA	04 (57.1)	03 (42.9)
Septicemia	03 (50.0)	03 (50.0)
Congenital pneumonia	01(20.0)	04 (80.0)
MAS	-	01 (100)

Table IV showed the distribution of the outcome of mechanically ventilated neonates by indications of MV.11 neonates were put on mechanical ventilation due to Respiratory Distress Syndrome, 5 (45.5%) neonates died and 6 (54.5%) survived. 7 neonates were put on mechanical ventilation due to Perinatal asphyxia, 4 (57.1%) died and 3 (42.9%) were survived. 6 neonates were put on mechanical ventilator due to Septicemia, 3 (50.0%) died and 3 (50.0%) were survived. No patient with MAS died.

Table V: Distribution of outcome of mechanically ventilated neonates by initial blood gas parameters

Initial Blood gas Parameters	Death (*n*=13) Mean ± SD	Survivor (*n*=17) Mean ± SD	*p* value (<0.05)
P^H	7.22 ± 0.12	7.32 ± 0.07	0.007
PCO_2	67.02 ± 14.46	51.15 ± 10.08	0.001
PO_2	55.05 ± 15.72	86.37 ± 23.93	
HCO_3	12.24 ± 5.71	20.57 ± 3.80	

Table V showed the outcome of MV infants by initial blood gas parameters. Mean P^H of death patient was 7.22 ± 0.12 and survivor was 7.32 ± 0.07, p value 0.007 (<0.05) which was statistically different, Mean Initial $PC0_2$ of death patient was 67.02 ± 14.46 mmHg and survivor was 51.15 ± 10.08 mmHg, p value 0.001 (<0.05), the difference was statistically significant. Mean Initial $P0_2$ of death patient was 55.05 ± 15.72 mmHg and survivor was 86.37 ± 23.93 mmHg. p value was 0.001 (<0.05). The Mortality was increased with the severity of acidosis.

DISCUSSION

The study included 30 mechanically ventilated neonates. Seventy three percent (22 cases) of the neonates were preterm and 8 cases (26.7%) were term. The mean gestational age was 32.59 ± 3.54 weeks. Tortman discovered that the average gestational age of infants needing mechanical ventilation were 35.2 ± 2.6 weeks[17]. Preterm, low birth weight neonates required more ventilation because they were more susceptible to developing RDS and septicemia.

Male infants were predominant and male to female ratio was 1.7:1. Hossain et al. demonstrated a male predominance in his studies and ratio was 1.42:1[18].The mean birth weight of the ventilated neonates in this study were 1800 ± 741 gram of which 5 cases (16.7%) had normal birth weight (>2500 gm), 10 (33.3%) had LBW (<2500 gm), 12 (40.0%) had VLBW (<1500 gm) and 3 (10.0%) neonates had ELBW (<1000 gm). Among the babies 60.0% were inborn and 40.0% were outborn. Kishan et al. found that the majority of the baby were out born (78.0%) and 22.0% were inborn[19]. Results didn't match with this study as it is a military tertiary hospital and most of the babies were inborn.

RDS was the common indication for MV in present study comprising about 11(36.7%) of the cases requiring mechanical ventilation. The other indications for MV were Perinatal asphyxia 7 (23.3%), Septicemia 6 (20.0%), Congenital pneumonia in 5 cases (16.7%), and Meconium Aspiration Syndrome 1 (3.3%). Tortman showed RDS was 63.0% cases which is also similar to Nangia S et al. and Mathur NC et al.[6,17,20].

An arterial blood gas was done at the time of initiation of MV. Mixed acidosis was found in 22 (66.7%) patients, 5 (16.7%) patient had respiratory acidosis, 3 (10.0%) had metabolic acidosis. Acidosis was severe in PNA and Septicemia than RDS. Initial ventilator settings were determined according to indication for mechanical ventilation. Ventilator rate was 40-50/min

almost all cases; PIP was 18 cm H_20 in RDS, Pneumonia, MAS and 16 cm H_20 in PNA, Septicemia. PEEP 4-5 cm H_20 and FiO_2 was 80-90%.

In this study the mean age at onset of mechanical ventilation was 2.9 ± 5.23 days, mean duration was 4.1 ± 2.61 days. Among 30 ventilated neonates 13 (43.3%) were died in this study. Hossain MM et al. showed death rate of ventilated neonates as 70.6%[17]. Death rate of this study differed from current study but a study in West Indies by H Tortman showed 59.0% survival and 41.0% death which is similar to this study[18]. Hossain MM showed the overall survival rate was 24.5%[21]. But survival rate was higher in developed countries (91.0%) by Singh M et al.[22]. Variations in the outcomes of ventilated neonates between developed and developing countries may be attributed to the ready availability of surfactant and parenteral nutrition in developed countries, which is less accessible in developing countries.

Among the death cases preterm neonates died more (50.0%) than term (25.0%). Female neonates died more (45.5%) than male (42.1%), outborn died more (58.3%) than inborn (33.3%) Low birth weight infants died more (48.0%) than that of normal birth weight (20.0%). Nangia S et al. showed in their study that survival rates increased with increasing birth weight changing from 25.0% for <1000 gm to 53.0% for >2500 grams[6].

In this study, the total number of deaths was 13. Among them more death occurred due to RDS 5 (45.5%). No neonate died due to MAS. Total 11 neonates were put on mechanical ventilation due to RDS. Among them 5 (45.5%) patients died and 6 (54.5%) survived. This indicates that neonates with RDS require mechanical ventilation more frequently and prognosis is good. Tortman reported that infants who needed mechanical ventilation for RDS had a 42.0% mortality rate, which is consistent with this study. However, he noted that the non-survivors in his study tended to be smaller and less mature infants[20].

Conditions associated with increased mortality in this study were Perinatal asphyxia and Septicemia. In Perinatal Asphyxia 4 (57.1%) neonates died and 3 (42.9%) survived which was almost similar to the study done in India (51.0%)[20]. Hypoxic Ischemic Encephalopathy results from anoxic injury to the brain and the ones requiring ventilation is extremely poor[21]. In Septicemia 3(50.0%) patients died and 3 (50.0%) were survived. That means mortality was high in Septicemic patient requiring mechanical ventilation. This is expected as neonate with septicemia who required ventilation ware severely ill. Maiya et al. found that all infants with sepsis who required mechanical ventilation survived[23]. Lindroth's study revealed an increase in survival rates from 45% to 69% over the study period, attributed to earlier diagnosis and treatment[24].

CONCLUSION

In this study, the most common causes of Mechanical Ventilation (MV) were Respiratory Distress Syndrome followed by Perinatal asphyxia and Septicemia. Outcome was good in RDS and poor in Septicemia and Perinatal asphyxia and they were the leading cause of death in this study.

LIMITATIONS OF THE STUDY

- Study design was not experimental.
- Sample size was small due to limitation of time.
- Outcomes according to mode of ventilation were not studied.
- Mean follow up time was 28 days following discharged from hospital, so long term outcome could not be evaluated in this study.

RECOMMENDATION

From the results and observation of this study it is recommended that further study should be carried out with larger sample size and longer duration of follow up to evaluate real outcome of mechanically ventilated neonates.

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