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Clinical Profile and Outcome of Mechanically Ventilated Neonates In A Resource-Limited Neonatal Intensive Care Unit

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ABSTRACT

Objective: To determine the clinical profile and outcome of mechanically ventilated neonates in a resource-limited neonatal intensive care unit.

Study Design: Prospective longitudinal study.

Place and Duration of Study: Department of Pediatrics Combined Military Hospital Sialkot Pakistan, from Apr to Sep 2022.

Methodology: Records of 150 neonates admitted to our neonatal intensive care unit (NICU) who underwent mechanical ventilation within the specified period were reviewed. We recorded their gestational age, birth weight, mode of delivery, APGAR scores, maternal medical history, admitting diagnosis and the indication for mechanical ventilation. They were followed for duration of ventilation, complications and outcomes. Chi square test was used to check for association between the variables.

Results: The most common indication for ventilation was severe respiratory distress with inability to maintain oxygenation in 104(69.33%) cases, followed by perinatal asphyxia with ineffective ventilation in 19(12.66%) cases. Notable associated conditions among ventilated neonates included sepsis in 57(38.00%) respiratory distress syndrome in 27(18.00%) and meconium aspiration syndrome in 18(12.00%) neonates. The frequency of survival for ventilated neonates was 52(34.66%).

Conclusion: The predominant reason for initiating mechanical ventilation was severe respiratory distress with inability to maintain oxygenation. Sepsis was the most frequent condition associated with mechanical ventilation.

Keywords: Mechanical Ventilation, Neonates, Perinatal Asphyxia, Respiratory Distress, Sepsis.

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INTRODUCTION

The neonatal intensive care unit (NICU) plays a crucial role in caring for and treating severely ill neonates. Mechanical ventilation (MV) is an essential component of any intensive care environment. MV serves as a life- support device, with the primary objective of oxygenating blood and eliminating carbon dioxide while minimizing potential lung damage.[1,2] The neonatal mortality rate is 42 per 1000 live births, which accounts for about 7% of all infant fatalities worldwide.[2] In developed regions, Pakistan and India, the neonatal mortality rate is 3, 42 and 29 per 1,000 live births, respectively.[3,4]

A crucial component of a newborn critical care unit is mechanical ventilation.[5] However, the efficient operation of the neonatal intensive care unit (NICU) depends not only on expensive high-tech equipment and complicated infrastructure, but also on the knowledge and skills of the medical and nursing staff as well as interdisciplinary assistance from the laboratory, radiology and physiotherapy.[6]

Many neonates who have to be hospitalized are severely ill and need

artificial breathing. The extensive use of mechanical ventilation in NICUs has dramatically increased the survival of ill newborns.[7] Weight and gestational age are significant predictors of newborn death, according to several studies.[7,8] Additionally, it is linked to the degree of sickness at the time of admission, difficulties with ventilator use, and the prevalence of co-morbid disorders such sepsis, coagulopathy, multiorgan failure and congenital abnormalities.[8]

The purpose of the current study was to identify prevalent causes of mechanical ventilation, potential links between underlying illnesses and neonatal survival, and problems that might arise during mechanical breathing.

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METHODOLOGY

This prospective longitudinal study was conducted at Combined Military Hospital Sialkot, Pakistan from April to September 2022. Prior approval from ERB of hospital was taken (ERC/07/2021).

Inclusion Criteria: All patients aged 28 days or less, of either gender, placed on mechanical ventilation were included.

Exclusion Criteria: Patients who left against medical advice or who were referred to another hospital were excluded.

Sample size was calculated using the WHO sample size calculator, based on an overall mortality rate of 20.20% in neonates admitted in (NICU).[9] The estimated sample size came out to be 150 neonates.

Using non-probability consecutive sampling, and after obtaining informed consent from parents/guardians, data was collected from the medical records of neonates who underwent mechanical ventilation. Indication for mechanical ventilation was any neonate who was unable to maintain SpO2 of more than 90% despite high flow oxygen. These were further classified as those with severe respiratory distress, perinatal asphyxia and apnea of prematurity. The gender, gestational age, birth weight, mode of delivery, APGAR scores at birth and five minutes, admitting diagnosis, indication for mechanical ventilation, duration of ventilation, and outcomes were recorded on a self- structured proforma. We closely monitored and documented various complications that could arise during mechanical ventilation. These complications included pneumothorax, hospital-acquired sepsis, ventilator-associated pneumonia, DIC, pulmonary hemorrhage, as well as other co- morbid conditions like shock, acute kidney injury, sepsis, intraventricular hemorrhage, and necrotizing enterocolitis.

Data was analyzed using Statistical Package for the Social Sciences (SPSS) version 23. Quantitative variables were presented using mean and standard deviation, while categorical variables using frequency and percentages. The association between birth weight, gestational age, and survival rates was examined using chi-square tests and statistical significance was determined using a threshold of $p \leq 0.05$. Independent variables included maternal medical issues, admitting diagnosis, indication for mechanical ventilation, duration of mechanical ventilation and ultimate outcomes.

RESULTS

The study revealed that out of 150 neonates the majority were male- 103(68.66%), delivered at term 119(79.33%), had a birth weight greater than 2500 grams-106(70.67%), were inborn 105(70.00%) and 95(63.33%) were delivered by caesarean section as shown in Table-I. Of a total of 150 neonates, 52(34.66%) neonates survived while 98(65.33%).

Table-I: Demographic Profile of Neonates requiring Mechanical Ventilation (n=150)

Variables	Categories	n (%)
Gender	Male	103(68.66%)
	Female	47(31.33%)
Birth Weight (grams)	< 1000 g	2(1.33%)
	1000 - 1499 g	24(16%)
	1500 - 2499 g	18(12%)
	> 2500 g	106(70.67%)
Gestational Age (weeks)	Early Preterm	20(13.13%)
	Late Preterm	11(7.33%)
	Term	119(79.33%)
Place of birth	Inborn	105(70.0%)
	Out born	45(30.0%)
Mode of delivery	NVD	55(36.66%)
	Cesarean section	95(63.33%)

Table-II revealed that the reason for initiation for ventilation varied. The majority of patients 104 (69.33%), required ventilation due to severe respiratory distress with inadequate oxygenation. Whereas perinatal asphyxia resulting in inadequate ventilation accounted for 19(12.66%) of cases, followed by recurrent apnea 11(7.33%), recurrent seizures-7 (4.66%), diaphragmatic hernia 4(2.66%), and ventilation during surgery in 5(3.33%) neonates.

Table-II: Indications for initiating Mechanical Ventilation (n=150)

Indications of Initiation for Ventilation	n(%)
Severe Respiratory Distress	104(69.33%)
Perinatal Asphyxia	19(12.66%)
Recurrent Apnea	11(7.33%)
Recurrent Seizures	7(4.66%)
Diaphragmatic Hernia	4(2.66%)
During Surgery	5(3.33%)

Table-III indicates the frequencies and percentages of diseases along with their corresponding survival outcomes observed in neonates who were shifted to mechanical ventilation. The most prevalent condition was sepsis, including pneumonia, meningitis, and necrotizing enterocolitis, affecting 57 neonates (38.00%), with 15(28.84%)

surviving. Respiratory distress syndrome of prematurity was noted in 27 neonates (18.00%), with only 2(3.84%) surviving. Meconium aspiration syndrome affected 18 neonates (12.00%), resulting in 9(18.00%) surviving. Birth asphyxia, observed in 15 neonates (10.00%), had a relatively higher survival rate of 12(24.00%). Apnea of prematurity and congenital pneumonia impacted 12(8.00%) and 6(4.00%) neonates, respectively, with survival rates of 8(16.00%) and 2(3.84%). Conversely, congenital heart disease and congenital diaphragmatic hernia each affected 6 neonates (4.00%), resulting in 1(1.92%) and 0 survivors, respectively. Post-operative surgical care was administered to 3 neonates (2.00%), with 3(5.76%) surviving.

Table-III: Diseases among Neonates and Survival Outcomes (n=150)

Diseases	n (%)	Surviving Neonates (n=52) n (%)
Sepsis (including pneumonia, meningitis, necrotizing enterocolitis)	57(38.0%)	15(28.84%)
Respiratory Distress Syndrome of Prematurity	27(18.0%)	2(3.84%)
Meconium Aspiration Syndrome	18(12.0%)	9(18.0%)
Birth Asphyxia	15(10.0%)	12(24%)
Apnea of Prematurity	12(8.0%)	8(16.0%)
Congenital Pneumonia	6(4.0%)	2(3.84%)
Congenital Heart Disease	6(4.0%)	1(1.92%)
Congenital Diaphragmatic Hernia	6(4.0%)	0.00
Post-Operative Surgical Care	3(2.0%)	3(5.76%)

In Table-IV complications were observed in a subset of patients in the study. The most prevalent complication was shock, affecting 70(46.66%) patients. Hospital-acquired sepsis was observed in 47(31.33%) of cases, while acute kidney injury, disseminated intravascular coagulation, pulmonary hemorrhage, and pneumothorax were reported in 14(9.33%), 8(5.33%), 4(2.66%), and 7(4.66%) of patients, respectively.

Table-IV: Complications of Neonates on Mechanical Ventilation (n=150)

Complications	n(%)
Shock	70(46.66%)
Hospital-acquired sepsis	47(31.33%)
Acute Kidney Injury	14(9.33%)
Disseminated Intravascular Coagulation	08(5.33%)
Pulmonary hemorrhage	4(2.66%)
Pneumothorax	7(4.66%)

Table-V shows the association between complications and survival status among 150 mechanically ventilated neonates. Shock was the most prevalent complication, observed in 25(48.1%) surviving neonates and 45 (46.0%) non-survivors. Similarly, hospital-acquired sepsis affected 14(26.9%) survivors and 33(33.7%) non-survivors. The occurrence of acute kidney injury was noted in 6(11.5%) survivors and 8(8.2%) non-survivors. Disseminated intravascular coagulation, pulmonary hemorrhage, and pneumothorax showed frequencies of 5(9.6%), 1(1.9%), and 1(1.9%) among survivors, respectively, compared to 3(3.1%), 3(3.1%), and 6(6.1%) among non-survivors. No statistically significant differences were found in the prevalence of complications between neonates who survived and those who did not (p>0.05).

Table-V: Association between Complications and Survival Status among Mechanically Ventilated Neonates (n=150).

Complications	Mechanically ventilated Neonates		*p*-value
	Survived (n=52) n(%)	Not survived (n=98) n(%)	
Shock	25(48.1%)	45(46.0%)	0.801a
Hospital-acquired sepsis	14(26.9%)	33(33.7%)	0.396a
Acute Kidney Injury	6(11.5%)	8(8.2%)	0.560b
Disseminated intravascular coagulation.	5(9.6%)	3(3.1%)	0.126b
Pulmonary hemorrhage	1(1.9%)	3(3.1%)	1.000b
Pneumothorax	1(1.9%)	6(6.1%)	0.422b

a Chi square test; b Fisher exact test.

DISCUSSION

In our study the majority of the patients were male, accounting for 68.66% of the total, while females made up 31.33% of neonates on mechanical ventilation. This is consistent with previous studies, including one by Sultana *et al.* which stated that 69% were male infants, and 30.2% were female infants.[10,11] In our study, we observed that the majority of neonates were delivered at term (79.33%), had a birth weight greater than 2500 grams (70.67%), were inborn (70%), and were delivered by caesarean section (63.33%). These findings are consistent with those reported by Sultana et al. (2019), where cesarean section was the preferred mode of delivery (71.7%), followed by normal vaginal delivery (NVD) (28.3%). Furthermore, in their study, a significant proportion of neonates were preterm (79.2%), similar to our

findings, and the majority were inborn (58.5%), aligning with our observation of 70% inborn neonates. However, there are differences in the distribution of birth weights among the studies, with our study reporting a higher proportion of neonates with birth weights greater than 2500 grams.[11]

Our study reveals that out of the total neonates, 52 survived, constituting 34.66% of the sample, while 98 did not survive, representing 65.33% of the sample. This survival rate is consistent with the findings of another study, who reported a survival rate of 35.8%.[11] Specifically, it is comparable to slightly higher mortality rates of 52%, 51%, 43.3%, and 48% as reported by Khushdil *et al.,* (2018),[12] Iqbal *et al.,* (2015)[13] and Mokhtar *et al.,* (2021)[14] respectively.

In our study involving 150 patients, ventilation was primarily initiated due to severe respiratory distress (69.33%), followed by perinatal asphyxia (12.66%), recurrent apnea (7.33%), recurrent seizures (4.66%), diaphragmatic hernia (2.66%), and surgery-related ventilation (3.33%). Other studies have reported similar findings, with severe respiratory distress being the most common indication (70%), followed by birth asphyxia (12%), recurrent apnea (8%), recurrent seizures (4%), and post-surgery complications (4%), with diaphragmatic hernia being rare (2%).[15]

In terms of disease pattern observed in neonates, our study found the most prevalent was sepsis affecting 38% neonates followed by respiratory distress syndrome (18%). This is comparable to one study, which found sepsis (35.8%) being most prevalent followed by respiratory distress syndrome (20.8%).[16]

In our study, complications such as Shock (46.66%), Hospital-acquired sepsis (31.33%), acute kidney injury (9.33%), disseminated intravascular coagulation (5.33%), pulmonary hemorrhage (2.66%), and pneumothorax (4.66%) were observed among patients. Alharbi *et al.* (2018) reported Sepsis (60.26%), meconium aspiration syndrome (13.90%), prematurity (6.62%), respiratory distress syndrome (4.63%), and birth asphyxia (4.63%) as the most common complications, with less frequent occurrences of other complications.[17]

Our study found that among 52 survived neonates shock as the most prevalent complication, affecting 25 patients (48.1%), followed by hospital-acquired sepsis observed in 14 neonates (26.9%). Additionally, acute kidney injury was noted in 6 neonates (11.5%), while disseminated intravascular coagulation and pulmonary hemorrhage were less frequent, affecting 5(9.6%) and 1(1.9%) neonate, respectively. Similarly, pneumothorax was observed in 1 neonate (1.9%). The *p*-values for all complications were less than 0.05, indicating statistical significance in their association with survived neonates. In a study by van Kaam *et al.,* multiple regression analysis revealed significant associations of various variables, including shock, with neonatal survival. Similarly, a study conducted in Kerala by Prabha *et al.,* found shock to be the most common complication, with a high survival rate.[18]

LIMITATION OF STUDY

The limitations of this study include a small sample size of only 150 neonates and that this study is done in a resource-limited setup with limited available laboratory investigations.

CONCLUSION

The predominant reason for initiating mechanical ventilation was severe respiratory distress resulting in ability to maintain oxygenation. Sepsis was the most frequent condition associated with ventilation. Among ventilated neonates, the survival rate stood at 34.66%. These overall findings from the study are promising, highlighting the necessity for establishing new neonatal intensive care units (NICU) in our country.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

RA & MA: Data acquisition, data analysis, critical review, approval of the final version to be published.

FB & AI: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

WM & AH: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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