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Outcome of Neonates with Meconium Aspiration Syndrome on High Frequency Oscillatory Ventilation in NICU of Tertiary Care Centre

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Abstract

Background: Meconium Aspiration Syndrome (MAS) is a complex respiratory disease of the term and near-term neonate. Inhalation of meconium causes airway obstruction, atelectasis, epithelial injury, surfactant inhibition and pulmonary hypertension, the chief clinical manifestations of which are hypoxemia and poor lung compliance. Supplemental oxygen is the mainstay of therapy of MAS, with around one-third of infants requiring mechanical ventilation. For those ventilated, high ventilator pressures, as well as relatively long inspiratory time and slow ventilatory rate, may be necessary to achieve adequate oxygenation. High frequency ventilation may offer a benefit in infants with refractory hypoxemia and/or gas trapping. High-frequency oscillatory ventilation (HFOV) is a lung-protective strategy that can be utilized in the full spectrum of patient populations ranging from neonatal to adults with acute lung injury. HFOV uses low tidal volumes and constant mean airway pressures in conjunction with high respiratory rates to provide beneficial effects on oxygenation and ventilation, while eliminating the traumatic "inflate–deflate" cycle imposed by CV. Few studies have shown that, HFOV can effectively improve lung ventilation and oxygenation function, shorten ventilator treatment time and reduce the incidence of air leakage for neonatal MAS, making it a safe and effective treatment method. **Objective:**To study the Outcome of Neonates with Meconium Aspiration Syndrome on High Frequency Oscillatory Ventilation (HFVO). **Material & Methods:** It is a Prospective Observational Study of 10 neonates >34 weeks of gestation and birth weight >1500gm with meconium-stained liquor with respiratory distress requiring mechanical ventilation. Study was conducted over a period of 10months from August 2021 to May 2022. These neonates requiring mechanical ventilation were electively first hand put on SensorMedics 3100A High Frequency Oscillatory Ventilator after taking informed written consent from parents and given appropriate Intensive care. Data was analyzed at the end of the study duration and looked for outcome in the form of successful weaning from mechanical ventilation and discharge from NICU, and Death. **Results:** 8 out of 10 (80%) neonates with MAS that were ventilated via HFOV were successfully weaned from mechanical ventilation and discharged, while death was reported in 2 out of 10 (20%) of the neonates included in the study. **Conclusion:** 80% of neonates with MAS that were provided mechanical ventilation in the form of HFOV were effectively weaned off from mechanical ventilation, whereas 20% neonates

Keywords:- High Frequency Oscillatory Ventilation and HFOV and Meconium Aspiration Syndrome and Outcome.

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INTRODUCTION

Meconium Aspiration Syndrome (MAS) is a complex respiratory disease of the term and near-term neonate. Inhalation of meconium causes airway obstruction, atelectasis, epithelial injury, surfactant inhibition and pulmonary hypertension, the chief clinical manifestations of which are hypoxemia and poor lung compliance. Supplemental oxygen is the mainstay of therapy of MAS, with around one-third of infants requiring mechanical ventilation. For those ventilated, high ventilator pressures, as well as relatively long inspiratory time and slow ventilatory rate, may be necessary to achieve adequate oxygenation. Meconium aspiration syndrome (MAS) is complex respiratory disease of the term and near-term neonate that continues to place a considerable burden on neonatal intensive care resources worldwide. The condition has features that make it stand alone amongst neonatal respiratory diseases—the unique combination of airflow obstruction, atelectasis, and lung inflammation, the high risk of coexistent pulmonary hypertension, and the fact of these occurring in a term infant with a relatively mature lung structurally and biochemically. For all these reasons, management of MAS, and in particular the ventilatory management of MAS, has been a difficult challenge for neonatologists down the years.[1,2,3,4,5,6]

MAS is complex respiratory disease of the term and near-term neonate, which continues to place a considerable burden on neonatal intensive care resources worldwide. Foetal distress during labour causes intestinal contractions as well as relaxation of the anal sphincter, which allows meconium to pass into the amniotic fluid and contaminate the amniotic fluid. Due to hypoxia, the foetus is going to experience transient apnoea and then starts breathing heavily, migration of meconium down the tracheobronchial tree initially causes obstruction of airways of progressively smaller diameter, which results in respiratory infections, lung inflammation and a series of clinical manifestations. MAS is most commonly seen in full-term and post term new borns than in preterm new borns. The incidence of MSAF in live births is of 9-16%, but however, only 1.2-1.6% of the cases result in MAS. The mortality rate after occurrence of MAS can be as high as 40%.[7,8,9,10]

Term neonates who are admitted with a diagnosis of MAS continue to represent a high-risk population with significant morbidity, and they often require intensive therapies.[7]

HFVO is a form of mechanical ventilation that uses supra-physiological breathing rates and very low tidal volume (0.5-2 ml/kg). The Tidal volume is barely greater than the dead space. In HFVO, both inspiration and expiration is active. This facilitates independent oxygenation and ventilation. Oxygenation is achieved by sustained inflation and recruitment of the lungs by the application of continuous distending pressure. Ventilation is achieved by the imposition of an oscillating waveform with variable frequency and amplitude. Gas transport during HFOV is complex and involves a range of different mechanisms, including bulk convection, turbulence, asymmetric velocity profiles, pendelluft, cardiogenic mixing, laminar flow with Taylor dispersion, collateral ventilation, and molecular diffusion. Except for molecular diffusion, each mechanism involves generation of convective

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fluid motion, and is influenced by the mechanical characteristics of the intubated respiratory system and the ventilatory settings. These factors have important consequences for the damping of the oscillatory pressure waveform and the drop in mean pressure from the airway opening to the lung.[5]

High frequency ventilation may offer a benefit in infants with refractory hypoxemia and/or gas trapping. High-frequency oscillatory ventilation (HFOV) is a lung-protective strategy that can be utilized in the full spectrum of patient populations ranging from neonatal to adults with acute lung injury. HFOV uses low tidal volumes and constant mean airway pressures in conjunction with high respiratory rates to provide beneficial effects on oxygenation and ventilation, while eliminating the traumatic "inflate–deflate" cycle imposed by CV. High-frequency oscillation is a safe and effective rescue mode of ventilation for the treatment of acute respiratory distress syndrome (ARDS). All patients who have ventilator-induced lung injury (VILI) or are at risk of developing VILI or ARDS would be suitable candidates for HFOV, especially those who have failed conventional mechanical ventilation.[2]

HFOV can reduce the extent of lung injury caused by local lung overexpansion and repeated alveolar opening and closing, optimise the ventilation effect, and reduce the occurrence of air leakage. It can also significantly alleviate PaCO2 issues and effectively maintain this aspect at normal levels, thus avoiding the risk of cerebral vasodilation and increased cerebral blood flow caused by hypercapnia. HFOV can effectively improve lung ventilation and oxygenation function, shorten ventilator treatment time and reduce the incidence of air leakage for neonatal MAS, making it a safe and effective treatment method.[3]

When compared to mechanical ventilation, the ventilation time, duration of oxygen therapy and hospitalization time were significantly shorter indicating that HFOV has significant therapeutic effect in treating MAS. As compared to the normal frequency ventilation, HFOV has advantages such as low tidal volume, low airway pressure, low-cut cavity pressure and positive end-expiratory pressure, which avoid making the alveoli open and close repeatedly, causing no shear force, keeping the alveoli under continuous uniform expansion, hence maintaining effective aeration and ventilation. The low airway pressure can reduce barotrauma, and also does not conflict with the new-born's individual spontaneous breathing.[9]

With the use of HFVO, the effectiveness of function inhaled oxygen concentration, oxygenation index, and arterial oxygen tension/alveolar arterial oxygen tension, partial pressure of oxygen, partial pressure of carbon dioxide, transcutaneous arterial oxygen saturation showed superior results when compared with conventional ventilator.[10]

Over the past decade, several new therapies have been suggested to be more effective than "conventional" management in treating meconium aspiration syndrome. These include: anti-inflammatory drugs, medications to counter the effect of prostaglandin-related compounds, high-frequency ventilation, exogenous surfactant, inhaled nitric oxide and liquid ventilation. There are, however, scant evidence-based data to justify routine use of any

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of those therapies. Additional prospective, well-controlled, randomized trials of diverse therapies are needed to elucidate the optimum management of MAS.[4]

For the purpose of the paper, MAS is defined as respiratory distress occurring soon after delivery in a meconium-stained infant, which is not otherwise explicable and is associated with a typical radiographic appearance.[6]

This paper focuses on the outcome of neonates with meconium aspiration syndrome on High Frequency Oscillatory Ventilation (HFVO) in the form of successful weaning from mechanical ventilation and discharge from NICU, and Death.

MATERIAL AND METHODS

This was a prospective observational study conducted in the Pediatric Department of a tertiary care hospital. Neonates admitted in NICU were enrolled for the study as per the criteria given. Study was conducted over a period of 10 months from August 2021 to May 2022. 10 neonates >34 weeks of gestation and birth weight >1500gm with meconium-stained liquor with respiratory distress requiring mechanical ventilation were selected for the study. These neonates requiring mechanical ventilation were electively first hand put on SensorMedics 3100A High Frequency Oscillatory Ventilator after taking informed written consent from parents and given appropriate Intensive care. Data was analyzed at the end of the study duration and looked for outcome in the form of successful weaning from mechanical ventilation and discharge from NICU, and Death.

Inclusion Criteria

- Neonates more than 34 weeks of Gestation.
- Neonates with birth weight more than 1500gm.
- Neonates with meconium-stained liquor with respiratory distress within 24hrs of birth and requiring mechanical ventilation.

Exclusion Criteria

- Neonates less than 34 weeks of Gestation.
- Neonates with birth weight less than 1500gm.
- Neonates with clear liquor with respiratory distress within 24hrs of birth and requiring mechanical ventilation.
- Neonates diagnosed with other lung parenchymal diseases.
- Neonates with congenital lung malformation.

RESULTS

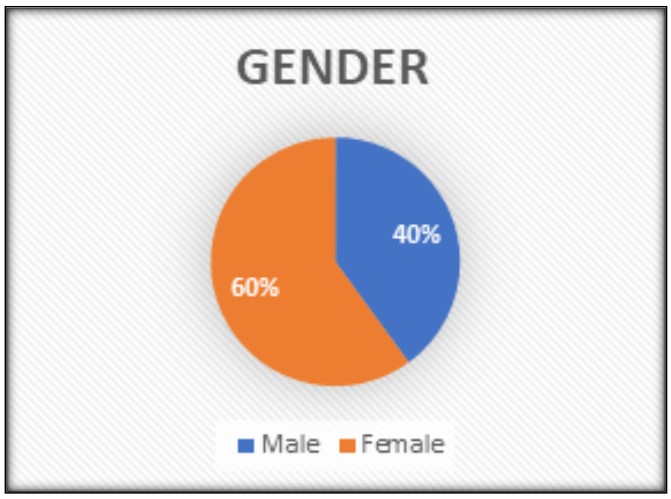

Figure 1: Gender distribution of study cases

As per data collected from 10 study subjects, 6 were Females (60%) and 4 were Males (40%). Male to Female ratio 0.6:1.

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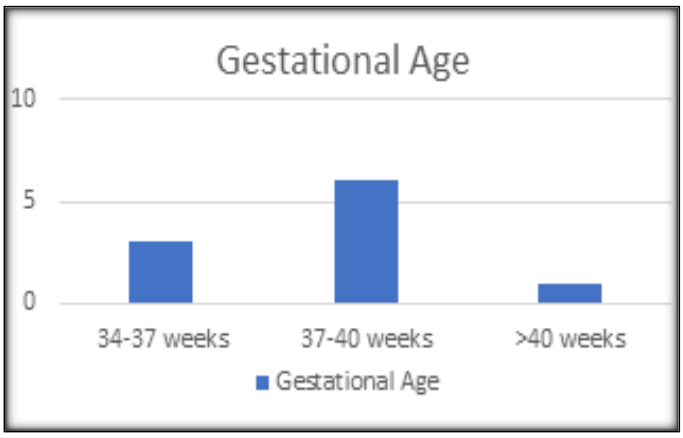

Figure 2: Distribution of study cases as per Gestational Age

Out of 10 Neonates, 3 belonged to gestational age between 34-37 Weeks (30%), 6 were between 37-40 Weeks (60%) and 1 was >40 Weeks (10%).

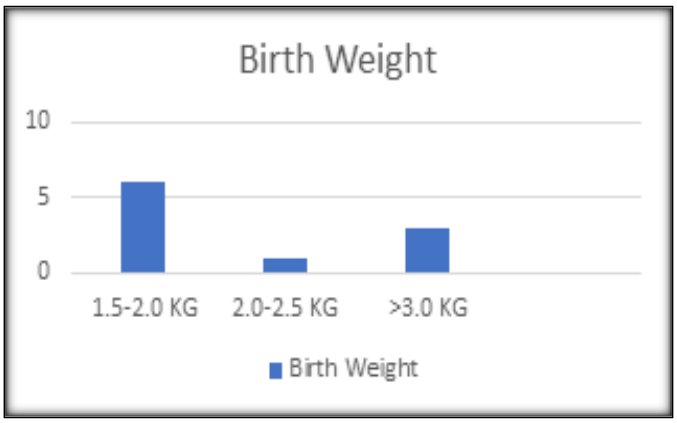

Figure 3: Distribution of study cases as per birth weight

Out of 10 Neonates studied, 6 weighed between 1.5-2.0 Kg at birth (60%), 1 weighed between 2.0-2.5 Kg (10%) and 3 weighed >3.0 Kg (30%).

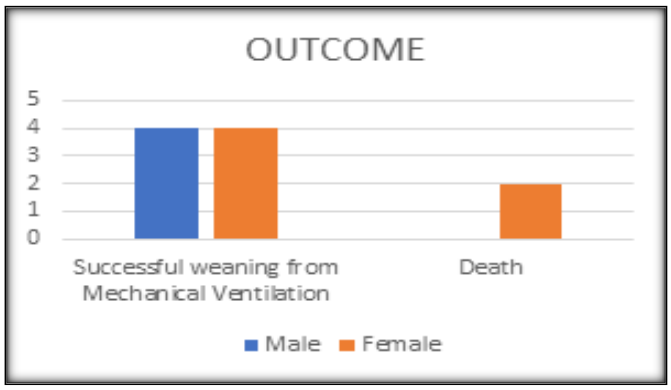

Figure 4: Outcome of Neonates with Meconium Aspiration Syndrome on HFOV

Out of 10 Neonates included in the study, 8 were successfully weaned from Mechanical Ventilation (HFOV) ie 80%; 4 Males and 4 Females whereas death was reported in 2 out of 10 neonates ie 20% both of which were Females.

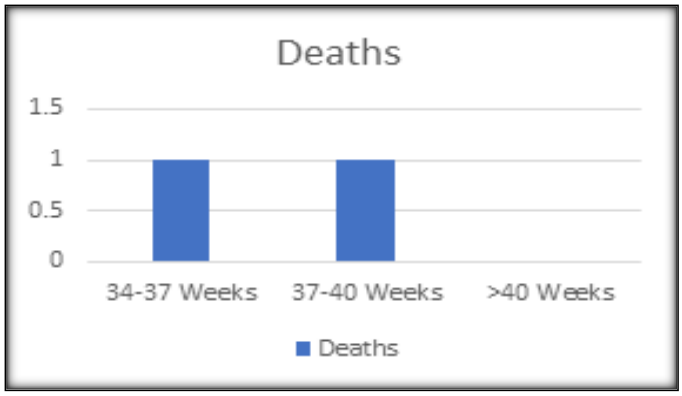

Figure 5: Deaths as per Gestational Age

Of the 2 deaths reported, 1 each was from Gestational Age between 34-37 Weeks (50%) and 37-40 Weeks (50%) . No death was reported in the Gestational Age group >40 Weeks.

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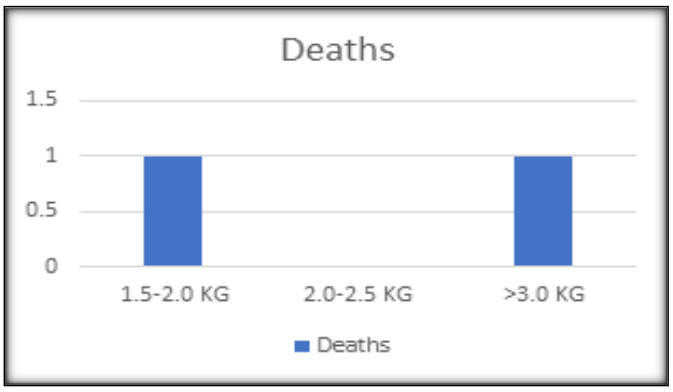

Figure 6: Deaths as per Birth Weight

Of the 2 deaths reported, 1 each was from Weight band between 1.5-2.0 Kg (50%) and >3.0 Kg (50%). No death was reported in the Weight band between 2.0-2.5 Kg.

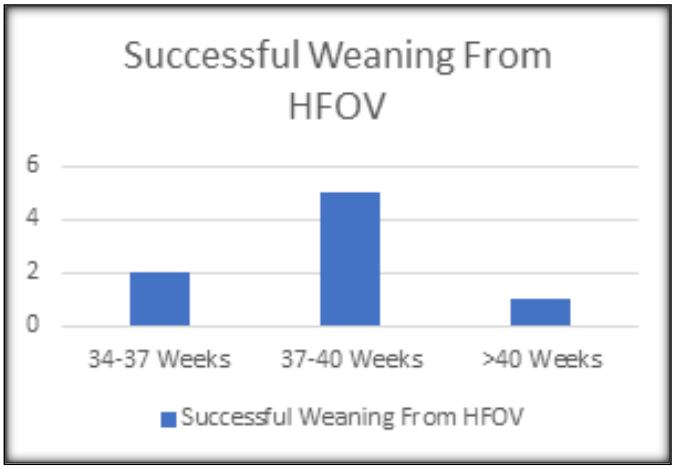

Figure 7: Successful Weaning from HFOV as per Gestational Age

Of the 8 Neonates successfully weaned from HFOV, 2 were from Gestational Age between 34-37 Weeks (25%), 5 were between 37-40 Weeks (62.5%) and 1 was from Gestational Age group >40 Weeks (12.5%).

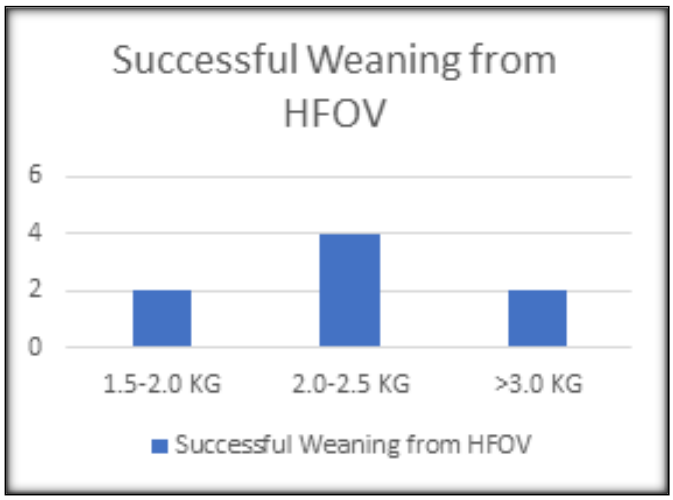

Figure 8: Successful Weaning from HFOV as per Birth Weight

Of the 8 Neonates successfully weaned from HFOV, 2 weighed between 1.5-2.0 Kg (25%), 4 weighed between (50%) and 2 weighed >3.0 Kg (25%).

DISCUSSION

The present study was a hospital based prospective observational study conducted in the Department of Pediatrics of a Tertiary Care Hospital. A total of 10 cases of neonates with Meconium Aspiration Syndrome requiring Mechanical Ventilation were studied over a period of 10 months. These neonates were electively first hand mechanically ventilated using SensorMedics 3100A High Frequency Oscillatory Ventilator. As per data collected from 10 study subjects, 6 were Females (60%) and 4 were Males (40%) with a Male to Female ratio 0.6:1. Out of 10 Neonates studied, 6 weighed between 1.5-2.0 Kg at birth (60%), 1 weighed between 2.0-2.5 Kg (10%) and 3 weighed >3.0 Kg (30%); and 3 belonged to gestational age between 34-37 Weeks (30%), 6 were between 37-40 Weeks (60%) and 1 was >40 Weeks (10%).

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The outcome was studied in the form of successful weaning from mechanical ventilation and discharge from NICU, and Death. Out of 10 Neonates included in the study, 8 were successfully weaned from Mechanical Ventilation (HFOV) ie 80%; 4 Males and 4 Females whereas death was reported in 2 out of 10 neonates ie 20% both of which were Females. Of the 2 deaths reported, 1 each was from Weight band between 1.5-2.0 Kg (50%) and >3.0 Kg (50%). No death was reported in the Weight band between 2.0-2.5 Kg and; of the 2 deaths reported, 1 each was from Gestational Age between 34-37 Weeks (50%) and 37-40 Weeks (50%) . No death was reported in the Gestational Age group >40 Weeks.

Of the 8 Neonates successfully weaned from HFOV, 2 were from Gestational Age between 34-37 Weeks (25%), 5 were between 37-40 Weeks (62.5%) and 1 was from Gestational Age group >40 Weeks (12.5%) and; of which 2 weighed between 1.5-2.0 Kg (25%), 4 weighed between (50%) and 2 weighed >3.0 Kg (25%).

In our study, mechanical ventilation using High Frequency Oscillatory Ventilation showed promising results in neonates with Meconium Aspiration Syndrome, with limitations of the study due to small sample size and lack of comparison with Conventional Ventilators in the form of various oxygenation parameters and outcome.

The promising results of using HFOV in Meconium Aspiration Syndrome were probably due to low tidal volumes and constant mean airway pressures in conjunction with high respiratory rates to provide beneficial effects on oxygenation and ventilation, while eliminating the traumatic "inflate–deflate" cycle.

CONCLUSIONS

80% of neonates with MAS that were provided mechanical ventilation in the form of HFOV were effectively weaned off from mechanical ventilation, whereas 20% neonates died. This shows clinical effectiveness of HFOV in MAS making it a safe and effective treatment modality in neonates with MAS. Few similar studies have concluded that using HFOV as the initial mode of ventilation in neonates with severe MAS is an effective strategy.

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