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Original article

Continuous Positive Airway Pressure versus Conventional Mechanical Ventilation in the Management of Neonatal Meconium Aspiration Syndrome

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Abstract

Background: Meconium aspiration syndrome (MAS) is one of the most common causes of severe respiratory failure in infants born at term or post-term gestation. Aim and objectives: To assess continuous positive airway pressure versus conventional mechanical ventilation in the management of neonatal meconium aspiration syndrome. Patient and methods: This prospective randomized controlled trial was conducted on fifty newborns admitted to the NICU of Benha University Hospitals and Benha Insurance Hospital with meconium aspiration syndrome (MAS). They were divided into two groups: Group 1: 25 cases were treated by conventional mechanical ventilation (CMV), and Group 2: 25 cases were treated by Continuous Positive Airway Pressure (CPAP). Results: There was no statistically significant difference between the studied groups with regard to maternal age. There was a statistically significant increase in mechanical ventilation needs in group 2 compared to group 1. There was high statistically significant increase in total oxygen duration in group 1 compared to group 2. There was a statistically significant increase in hospital stays in group 1 compared to group 2. No parameter was associated with pulmonary hypertension in patients. Conclusion: Compared to conventional mechanical ventilation, our study produced evidence that CPAP in neonates with MAS reduces the subsequent need for MV, oxygen duration, hospital stay, and incidence of sepsis, with no significant correlation between total oxygen duration and maternal age, gestational age at delivery, Apgar 1 or 5.

Key words: Continuous Positive Airway Pressure; MAS; Conventional Mechanical Ventilation.

Introduction

Meconium aspiration syndrome (MAS) is one of the most common causes of severe respiratory failure in infants born at term or post-term gestation. Approximately 8 to 19% of all term deliveries occur through meconium-stained amniotic fluid (MSAF), and MAS develops in 5 to 33% of these infants [(1).]

Respiratory complications of MAS are often the consequence of hypoxia in utero, with significant acidosis and depressed respirations at birth. There also appears to

be a greater risk of developing MAS as well as all respiratory complications (that is, tachypnea, pneumonia, and pulmonary air leaks) if the meconium is 'thick' as opposed to 'thin' [2].

The respiratory signs of MAS are similar to those of other neonatal respiratory diseases. These include tachypnea, retractions, grunting, nasal flaring, and cyanosis. If the meconium has been presented in utero for greater than 3 h, the infant may have meconium staining of the skin, nails, and umbilical cord. The anterior-posterior diameter of the chest may be increased if there is significant air trapping [3].

The diagnosis of MAS may be assumed when three criteria are met: (1) a history of meconium in the trachea; (2) clinical evidence of significant respiratory distress; and (3) X-ray evidence of aspiration pneumonia. The association of transient tachypnea and MSAF without meconium in the airway or X-ray evidence of pneumonitis is often misdiagnosed as MAS and may lead to inappropriate treatment, including early positive pressure, which then may result in inadvertent pulmonary air leaks [4].

Approximately 30 to 50% of infants diagnosed with meconium aspiration syndrome will require continuous positive airway pressure (CPAP) or mechanical ventilation. The optimum modes of ventilation for MAS are not known [5].

Though ventilation is a life-saving measure, ventilation in itself results in ventilation-induced lung injury, and the need for MV translates into prolonged hospital stays, increased burden on the health care system, and increased treatment costs. Continuous positive airway pressure (CPAP) as a primary respiratory therapy in MAS has not been studied extensively. When NCPAP is applied to newborns with MAS, it may resolve atelectasis by expanding partially obstructed small airways and stabilizing the collapsing terminal airways to enhance oxygen exchange [6,7].

The aim of this study was to assess continuous positive airway pressure versus conventional mechanical ventilation in the management of neonatal meconium aspiration syndrome.

Patient and methods

This prospective randomized controlled trial was conducted on fifty newborns admitted to the NICU of Benha University Hospitals and Benha Insurance Hospital from 2018 to 2024 with meconium aspiration syndrome (MAS). They were divided into two groups: **Group 1:** 25 cases were treated by conventional mechanical ventilation (CMV), and **Group 2:** 25 cases were treated by Continuous Positive Airway Pressure (CPAP).

Inclusion criteria: Both sexes (males and females). The diagnosis of MAS was defined according to the following criteria, which basically consisted of history of fetal distress or asphyxia during delivery; thick meconium-stained amniotic fluid; meconium particles visible below the glottis; breathing difficulties combined with type II respiratory failure soon after birth; and a thoracic X-ray with pulmonary granular and patchy shadows [8].

Exclusion criteria: The presence of major congenital malformations: (i.e., congenital heart, cerebral, lung, and abdominal malformations), fetal hydrops, and a lack of parental consent.

Methods

All patients were subjected to the following: Detailed history taking (personal history of mother, present history (prenatal, natal, and postnatal history) and family history), examination (general examination and systematic examination included: (cardiovascular system, gastrointestinal tract (GIT) and abdomen, central nervous system (CNS) and musculoskeletal system, and chest examination), and investigations (chest X-ray, echocardiography , cranial ultrasonography, and routine laboratory investigations)

Outcome measures included: **Primary outcome are:** The need for MV in the first 7 days of life; the duration of assisted ventilation, duration of oxygenation, duration of hospitalization; and the need for surfactant and **Secondary outcome:** Occurrence of complications: bronchopulmonary dysplasia (BPD), Retinopathy of prematurity (ROP), intraventricular hemorrhage (IVH), pneumothorax, pulmonary hypertension, culture-positive sepsis (onset of sepsis >72 hours of birth), and mortality rate.

Ethical considerations: The study was approved by the Ethics Committee of Faculty of Medicine, NICU of Benha University Hospitals, and Benha Insurance Hospital, Benha, Egypt {13.7.2021}. There are adequate provisions to maintain privacy of participants and confidentiality of the data are as follows: The patients were given the option of not participating in the study if they did not want to. We put code numbers to each participant, with the name and address kept in a special file. We hide the patients' names when we do the research. We used the results of the study only in a scientific manner and not to use it in any other purpose.

Statistical analysis

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp) Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR). The used tests were: Chi-square test: for categorical variables, to compare different groups, Student t-test: for normally distributed quantitative variables, to compare between two studied groups, Mann-Whitney test: for nonparametric quantitative variables, to compare between two studied groups; Pearson correlation: for quantitative variables, to correlate between two variables; and Spearman correlation: for nonparametric variables, to correlate between two variables. A two-tailed P value ≤ 0.05 was considered statistically significant.

Results

There was no statistically significant difference between the studied groups with regard to maternal age. There was a statistically significant increase in mechanical ventilation needs in group 2 compared to group 1. There was a statistically significant increase in total oxygen duration in group 1 compared to group 2 **(Table 1).**

There was a statistically significant increase in hospital stays in group 1 compared to group 2 **(Table 2).**

No parameter was associated with pulmonary hypertension in patients **(Table 3).**

There was no statistically significant correlation between total oxygen duration with maternal age, gestational age at delivery, Apgar 1 or Apgar 5 **(Table 4).**

There was no statistically significant difference between the studied groups as regards BPD, ROP, IVH, pneumothorax, and pulmonary hypertension (P>0.05).

There was a statistically significant increase in sepsis in group 1 compared to group 2 (P=0.021) **(Figure 1).**

Table 1: Comparison between the studied groups as regard baseline data, mechanical ventilation and total oxygen duration

	Group 1 (n=25)		**Group 2 (n=25)**		**Test of sig.**	**P**
Maternal age (years)					**t= 1.217**	**0.230**
Range	**23 – 30**		**24 – 32**			
Mean ± SD	**26.44 ± 1.87**		**27.2 ± 2.5**			
Mode of Delivery	**No**	**%**	**No**	**%**		
CS	**12**	**48.0**	**13**	**52.0**	**χ^2=0.080**	**0.777**
NVD	**13**	**52.0**	**12**	**48.0**		
Neonate sex						
Female	**12**	**48.0**	**10**	**40.0**	**χ^2=0.325**	**0.569**
Male	**13**	**52.0**	**15**	**60.0**		
GA at delivery (weeks)						
Range	**37 – 40**		**37 – 40**		**t= 0.636**	**0.528**
Mean ± SD	**38.64 ± 0.81**		**38.48 ± 0.96**			
Apgar 1	**No**	**%**	**No**	**%**		
<5	**6**	**24.0**	**5**	**20.0**	**χ^2= 0.117**	**0.733**
≥5	**19**	**76.0**	**20**	**80.0**		
Apgar 5						
<7	**4**	**16.0**	**6**	**24.0**	**χ^2= 0.500**	**0.480**
≥7	**21**	**84.0**	**19**	**76.0**		
Ventilator parameters						
FIO2						
Mean ±SD	**55.6±13.6**		**51.5±11.1**		**t=0.57**	**0.60**
Range	**40-85**		**25-80**			
PEEP						
Mean ±SD	**6.5±0.8**		**6.3±0.9**		**t=0.43**	**0.66**
Range	**5-8**		**5-8**			
PIP						

Mean ±SD	**18.7±2.3**			
Range	**16-23**			
Rate				
Mean ±SD	**28.9±5.1**			
Range	**25-45**			
Total oxygen duration (hrs.)				
Range	**17 – 51**	**15 – 48**	**t=**	**<0.001***
Mean ± SD	**40.68 ± 9.71**	**27.04 ± 5.45**	**6.028**	

Table 2: Comparison between the studied groups as regard hospital stay

	Group 1 (n=25)	**Group 2 (n=25)**	**Test of sig.**	**P**
Hospital stays (days)				
Range	**4 – 6**	**4 – 5**	**U=**	**0.001***
Median (IQR)	**5 (4 – 6)**	**4 (4 – 4)**	**150.0**	

Table 3: Regression analysis for the parameters affecting pulmonary hypertension

Variable	**B**	**Std. Error**	**Wald**	**P value**	**Exp(B)**	**95% Confidence Interval for Exp(B)**	
						Lower Bound	**Upper Bound**
Maternal age	-0.309	0.240	1.661	0.197	0.734	0.459	1.174
GA at delivery	0.632	0.547	1.335	0.248	1.881	0.644	5.496
Apgar 1	-1.364	1.378	0.979	0.323	0.256	0.017	3.811
Apgar 5	0.033	1.500	0.0	0.983	1.033	0.055	19.529
Total oxygen duration	0.034	0.075	0.199	0.656	1.034	0.892	1.198
Hospital stay	0.967	1.027	0.886	0.347	2.630	0.351	19.702

Table 4: Correlation between total oxygen duration and some parameters

	r	**p**
Maternal age	**r_p=-0.154**	**0.286**
GA at delivery	**r_p=0.192**	**0.181**
Apgar 1	**r_s=0.164**	**0.254**
Apgar 5	**r_s=0.030**	**0.839**

r_p: Pearson coefficient r_s: Spearman coefficient

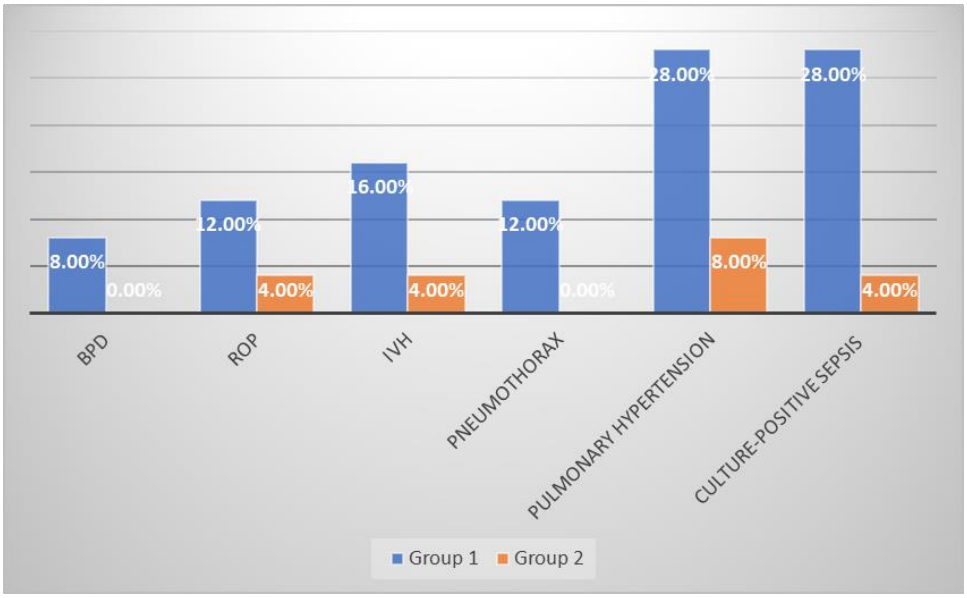

Figure 1: Comparison between studied cases according to complications

Discussion

Our study revealed that there was no statistically significant difference between the studied groups as regard neonate data (mode of delivery, neonate sex, gestational age at delivery (38.64 weeks in group 1 compared to 38.48 weeks in group 2)).

Supporting our results, Toro-Huamanchumo and colleague, 2022, in their meta- analysis including sixteen full-text articles, and three RCTs comparing the efficacy of CPAP compared to endotracheal intubation (ETI) in neonates with MAS reported that the mean gestational age in the studies was 38.5 weeks [(9).]

Montgomery and Rose, 2019, conducted their study on a total of 135 neonates who were randomly assigned to the treatment group (67 to the NCPAP group and 68 to the standard treatment group). Mean birth weight was 2944 g, the average gestation was 38.2 weeks, 41.5% male. Baseline characteristics between groups did not differ [(10).]

In the current study, there was a statistically significant increase in the need for mechanical ventilation in group 2 compared to group 1.

It was found that CPAP did not reduce mortality, the need for ventilation, or episodes of pneumothorax compared to ETI in neonates with MAS, and there were no significant differences in secondary outcomes including APGAR at one and five minutes, and length of hospitalization. Also, they showed that performing CPAP in neonates with MAS does not have a clinically significant benefit compared to performing ETI [(9).]

Compatible with our results, reported that the need for MV in the first 7 days of life was significantly lower in the infants randomized to the CPAP group compared to the MV group [(11).]

The current study demonstrated that there was a high statistically significant increase in total oxygen duration in group 1 compared to group 2.

In line with our results, reported that more infants in the hood oxygen group had a longer duration of oxygen requirement than in the NCPAP group [10].

Also, reported similar results, they found that the duration of oxygen was significantly higher in the MV group compared to the CPAP group.

According to our results, there was a statistically significant difference between the studied groups as regards hospital stay [11].

In the study involving 63 babies with respiratory distress, it was shown that 39 (61%) showed improvement of respiratory distress with bubble CPAP with confidence interval of 38–62%, whereas 24 (39%) babies required MV and other modalities [12]. This is consistent with the results of our study

In contrast to our results Pandita and colleagues, found that the hospital stay was similar between CPAP and MV groups [11].

In their prospective study, showed that out of enrolled 66 infants, 50 (76%) with moderate-to-severe MAS were managed with CPAP alone and concluded that the use of early CPAP resulted in a lesser need for ventilation. The duration of oxygen requirement, hospitalization, and ventilation is very similar to the results of our study [13].

In our study, there was a statistically significant increase in sepsis in group 1 compared to group 2.

Our results came in line with who reported that more infants in MV group had culture-positive sepsis than CPAP group [11].

Furthermore, it showed that more infants in the hood oxygen group developed culture positive sepsis than in the CPAP group [10].

In our study, no parameter was associated with pulmonary hypertension in patients.

MAS is often complicated by pulmonary vasoconstriction and severe pulmonary hypertension, which is a significant contributor to morbidity and mortality [14].

The exact mechanism by which this occurs is controversial, but it has been speculated that it is precipitated, at least in part, by fetal and neonatal hypoxia leading to pulmonary vascular constriction and eventually remodeling. In addition, animal models suggest that when the lung parenchyma is exposed to meconium pulmonary vasoconstrictor hormonal factors, such as thromboxane A2, angiotensin II, and cytokines are released, which in turn cause acute pulmonary vasoconstriction and pulmonary hypertension [15].

The current study showed no statistically significant correlation between total oxygen duration with maternal age, gestational age at delivery, Apgar 1 or Apgar 5.

Conclusion

Compared to conventional mechanical ventilation, our study produced evidence that CPAP in neonates with MAS reduces the subsequent need for MV, oxygen duration, hospital stay, and incidence of sepsis with no significant correlation between total oxygen duration and maternal age, gestational age at delivery, Apgar 1 or 5.

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