

Original Research Article

Continuous positive airway pressure in the treatment of meconium aspiration syndrome

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ABSTRACT

Background: Meconium aspiration syndrome (MAS) is a significant neonatal condition, often associated with meconium-stained amniotic fluid (MSAF), fetal distress and severe respiratory complications. Management involves various forms of respiratory support, with continuous positive airway pressure (CPAP) being an effective, non-invasive option. This study aimed to assess the outcomes of CPAP therapy in neonates with MAS and identify predictors of success and failure in a tertiary care setting.

Methods: A descriptive observational study was conducted at the Paediatric Department of RNT Medical College, Udaipur, from January 2024 to July 2024. A total of 77 neonates with MAS were enrolled, with data collected on maternal complications, delivery mode, clinical status, and neonatal outcomes. CPAP was initiated in most cases, and its effectiveness was monitored.

Results: Fetal distress was present most commonly in newborns with maternal complications (55.26%), followed by pregnancy-induced hypertension (19.74%). Most infants were born via C-section (42.1%), with a mean birth weight of 2.53 kg. CPAP was successful in 85.53% of cases, with predictors of success including lower Downe's scores. Severe asphyxia was the leading cause of mortality (13.16%).

Conclusions: CPAP is a highly effective treatment for moderate-to-severe MAS, offering advantages over mechanical ventilation in terms of reduced complications. Early initiation improves respiratory outcomes and reduces the need for invasive ventilation. Monitoring and early identification of risk factors, such as Downe's score, are crucial for optimizing management.

Keywords: Continuous positive airway pressure, Downe's score, Meconium aspiration syndrome, Neonatal respiratory distress

INTRODUCTION

Meconium aspiration syndrome (MAS) is a significant neonatal condition that pediatricians commonly encounter in the delivery room or newborn nursery. It occurs in approximately 5% of infants born with meconium-stained amniotic fluid (MSAF), which is present in 10-15% of births, particularly in term or post-term infants. Among these cases, 30% require mechanical ventilation, and 3-5% may not survive.¹ Fetal distress and hypoxia often precede the passage of meconium into the

amniotic fluid, with affected infants frequently presenting with meconium staining and requiring resuscitation at birth.

The National Neonatal-Perinatal Database of India (2002-03) defines MAS by the presence of two out of three criteria: meconium-stained liquor, respiratory distress within one hour of birth, and radiological evidence of aspiration pneumonia.² MAS pathophysiology involves aspiration of meconium into the lungs, causing airway obstruction, which leads to hyperinflation, atelectasis,

and respiratory distress. Hypoxemia, ventilation-perfusion mismatch, and decreased lung compliance are common features.³

A partial airway obstruction caused by meconium leads to a "ball-valve" effect, resulting in air trapping and overexpansion of the lungs. Complete obstruction can lead to atelectasis and impaired gas exchange.⁴ The condition often coexists with persistent pulmonary hypertension of the newborn (PPHN), creating a complex and multifactorial interplay that worsens respiratory distress and hypoxia.⁵

Management of MAS focuses on tailored respiratory support, ranging from nasal continuous positive airway pressure (CPAP) to advanced interventions like mechanical ventilation, high-frequency oscillatory ventilation, or extracorporeal membrane oxygenation (ECMO). CPAP plays a critical role in improving oxygenation by expanding small airways, stabilizing terminal airways, and addressing intrinsic positive end-expiratory pressure (PEEP). The application of CPAP also prevents air trapping, thereby improving ventilation-perfusion mismatch and reducing the work of breathing.

By understanding the pathophysiology of MAS and implementing timely interventions, neonatal outcomes can be optimized, reducing the morbidity and mortality associated with this condition.

METHODS

This descriptive observational study was conducted in the Pediatric Department of RNT Medical College, Udaipur, from January 2024 to July 2024, after obtaining institutional ethical committee approval. Informed written consent from parents was obtained prior to enrollment, as well as for procedures like ventilation and surfactant administration. The study included all neonates diagnosed with meconium aspiration syndrome (MAS), defined by the presence of meconium-stained amniotic fluid (MSAF) at birth, clinical evidence of respiratory distress within 6 hours of life, and chest X-ray findings consistent with aspiration pneumonia. A total of 77 cases were observed during the study period.

Method of data collection

Data was collected through a detailed history and clinical examination using a structured proforma, and relevant laboratory investigations such as CBC, CRP, blood cultures, ABG, and chest X-rays were performed. Enrolled infants were administered CPAP with parental consent, using available ventilators or bubble CPAP generators. Bilateral nasal prongs were applied, starting with a CPAP pressure of 5 cm, FiO₂ of 50%, and flow of 5 L/min, adjusted to maintain SpO₂ between 89%-95%. CPAP was weaned off when SpO₂ remained >90% with FiO₂ <25%, and mild respiratory distress. Post-extubation oxygen support was provided as needed, with gradual

weaning based on SpO₂ levels. Comorbid conditions were managed at the attending physician's discretion.

Inclusion criteria

Neonates with a gestational age greater than 34 weeks, enrolled within 24 hours of birth, who have been diagnosed with meconium aspiration syndrome (MAS) and require mechanical ventilation were included in the study.

Exclusion criteria

Neonates with a gestational age under 34 weeks, those with congenital heart diseases or severe congenital malformations, and cases of birth asphyxia were excluded from the study.

Statistical analysis

The data was compiled in an MS Excel sheet and analyzed using SPSS version 20. Appropriate statistical tests were applied to assess the significance of correlations between unmet needs and associated probable factors, with statistical analysis performed under the guidance of a qualified statistician. A p value of <0.05 was considered statistically significant.

RESULTS

In this study, fetal distress was the most common maternal complication, accounting for 55.26% of the cases. Pregnancy-induced hypertension (PIH) followed at 19.74%, while both preterm rupture of membranes (PROM) and oligohydramnios each represented 10.52% of the cases. Other maternal issues were less frequent, comprising 3.95% of the total cases (Table 1).

Table 1: Maternal factors associated with MAS.

Maternal data	No. of cases	Percentage
Fetal distress	42	55.26
PIH (pregnancy induced hypertension)	15	19.74
PROM (premature rupture of membranes)	8	10.52
Oligohydramnios	8	10.52
Others	3	3.95

In our study, babies with MAS born by caesarean formed the highest percentage (n=32, 42.10%) of cases followed by babies born by normal vaginal delivery (n=25, 32.90%). Babies born by outlet forceps delivery were (n=5, 6.58%) and by vacuum extraction were (n=14, 18.42%) (Table 2).

In this study, Downe's scores showed that 50% of cases had a score of 5, indicating moderate risk, with smaller

proportions having scores of 6 (24%), 4 (13%), and 7 (13%). The mean birth weight of babies with MAS was 2.53 kg (ranging from 1.5 to 3.5 kg). The majority of MAS cases were seen in babies weighing between 2.5-2.9 kg (35.53%), followed by those in the 2-2.5 kg range (27.63%), 3-3.5 kg range (21.05%), and 1.5-2 kg range (15.79%). Severe asphyxia was observed in 1.32% of cases, with 10.53% having an Apgar score of 6 (Table 3).

Table 2: Mode of delivery.

Mode of delivery	No. of cases	Percentage
Caesarean section	32	42.11
Normal delivery	25	32.89
Vacuum extraction	5	6.58
Forceps delivery	14	18.42

Table 3: Assessment of respiratory distress with Downe's score system.

Downe's score	No. of cases	Percentage
4	10	13.00
5	38	50.00
6	18	24.00
7	10	13.00
Total	76	100.00

The most common complication in this study was birth asphyxia (BA), affecting 32.89% of cases. Acute renal failure (ARF) followed closely at 19.74%, while septicemia was observed in 17.11% of the cases. Pneumothorax occurred in 7.89%, and pulmonary hemorrhage and pneumonia were less frequent, each affecting 3.95% of cases. Other complications not specified in the categories accounted for 18.42% (Table 4).

Table 4: Complications in MAS.

Complications	No. of cases	Percentage
ARF (acute renal failure)	15	19.74
BA (birth asphyxia)	25	32.89
Septicemia	13	17.11
Pneumothorax	6	7.89
Pulmonary hemorrhage	3	3.95
Pneumonia	3	3.95
Others	14	18.42

In this study, Downe's score was the most significant predictor of CPAP success or failure, with a notable difference between the success (5.2 ± 1.22) and failure (6.98 ± 0.56) groups ($p < 0.001$). Other factors like birth weight, gestational age, sex, Apgar scores, and CPAP initiation time showed no significant differences. While the failure group had a higher proportion of moderate to severe PPHN (37.5% vs. 14%), this was not statistically significant ($p = 0.06$). Severe birth asphyxia was the

leading cause of death, followed by acute respiratory failure, with 10 deaths (13.16%). CPAP was administered to 65 infants (85.53%), while 11 (14.47%) required ventilator support, with 10 of them dying (Table 5).

Table 5: CPAP success versus CPAP failure.

Predictor variable	Success (n=66) (%)	Failure (n=10) (%)	P value
Birth weight (g)	3066 $\pm$ 454	3096 $\pm$ 330	0.83
Gestational age (weeks)	38.94 $\pm$ 0.95	38.11 $\pm$ 0.96	0.13
Sex: Male	46 (69.69)	7 (70)	0.22
Apgar 1 min <5	12 (18.18)	6 (60)	0.34
Apgar 5 min <5	2 (3.03)	2 (20)	0.24
Downe's score	5.2 $\pm$ 1.22	6.98 $\pm$ 0.56	<0.001
Moderate and severe PPHN	7 (14)	6 (37.5)	0.06
Time of starting CPAP	6 $\pm$ 9 hours	3 $\pm$ 3.5 hours	0.2

DISCUSSION

This study evaluated the clinical profile of 76 babies with meconium aspiration syndrome (MAS), focusing on birth weight, gestational age, and immediate outcomes. Meconium staining of amniotic fluid, leading to MAS, was more common in cases of fetal distress, PIH, and post-term pregnancies.

In our study, fetal distress was the most common associated factor (55.26%), followed by PIH (19.74%), PROM (10.52%), and oligohydramnios (10.52%). Three cases (3.95%) had no associated factors. Coughtrey et al found fetal distress common in MAS infants, consistent with our findings.⁶ Kaur et al reported similar associations, with 51.72% fetal distress, 19.74% PIH, and 10.52% each of PROM and oligohydramnios.⁷ In this study, the highest percentage of babies with MAS were delivered by LSCS (42.10%), followed by normal vaginal delivery (32.90%), vacuum extraction (6.58%), and forceps delivery (18.42%). Similarly, Kaur et al reported 41.3% of MAS cases were born by caesarean section, 34.48% by normal vaginal delivery, and 17.24% by forceps delivery.⁷ These findings align with those of other authors, such as Narang et al, who found 54.2% of MAS babies were born by LSCS, 30.7% by normal vaginal delivery, and 11.8% by forceps delivery.⁸

In this study of 76 babies, the majority had moderate respiratory distress (50%), with a Downes score of 5 at admission. Twenty-eight babies had a Downes score >6 at admission. Gregory and Gooding et al demonstrated in puppies that meconium progressively moves to the periphery of the lungs with each breath, which aligns with the observation that many infants with meconium aspiration appear stable for a few hours before developing progressive respiratory distress.⁹ Similarly, Kaur et al found that most of their 29 babies had

moderate respiratory distress, with a Downes score between 4 and 6 at admission.⁷ One baby had a Downes score >6, and those who were ventilated developed progressive distress, reaching a maximum Downes score of 8.

In our study of babies with MAS, the most common complication was birth asphyxia (32.89%, n=25), followed by acute respiratory failure (ARF) in 19.74% (n=15) of cases. Septicemia was observed in 17.11% (n=13), pneumothorax in 7.89% (n=6), pulmonary hemorrhage in 3.95% (n=3), and pneumonia in 3.95% (n=3). Some babies had multiple complications. In the Kaur et al study, the most common complications were birth asphyxia (37.93%), acute respiratory failure (20.68%), septicemia (17.24%), and air leak syndrome (6.89%).⁷ Other complications, including pneumonia and pulmonary hemorrhage, were also noted. Wiswell TE et al found that 11.53% of babies developed pneumothorax. The National Neonatal Perinatal Database of India (2002-2003) reported perinatal asphyxia as the leading cause of death (40.5%) in babies born through MSAF, with an overall mortality rate of 11.6%.¹⁰

CONCLUSION

Meconium aspiration syndrome (MAS) is a leading cause of respiratory distress in newborns, characterized by meconium in the lungs. CPAP is an effective treatment for moderate-to-severe MAS, offering similar benefits to mechanical ventilation but with a lower risk of complications such as pulmonary leak syndrome, pneumonia, and hypotension. CPAP helps open the airways and facilitates airflow during both inspiration and expiration, preventing air trapping. Early initiation of CPAP reduces the need for mechanical ventilation and improves outcomes, minimizing associated complications.

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