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Research Article

# Efficacy of Bolus Surfactant Therapy in Neonates with Meconium Aspiration Syndrome: A Prospective Controlled Study

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**Article Info**

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## Abstract

**Background:** Meconium aspiration syndrome (MAS) is a major cause of respiratory distress in neonates. One contributing mechanism is meconium-induced impairment of surfactant function, which increases surface tension and makes alveoli more prone to collapse. This supports the rationale for bolus surfactant therapy.

**Methods:** This prospective controlled study at Shri Dada Dev Matri Avum Shishu Chikitsalaya, New Delhi, was conducted from January to December 2019. The study included 60 neonates with MAS, 30 in each group. The intervention group received a single surfactant bolus in addition to standard care, whereas controls received standard care alone. We compared respiratory parameters, duration of respiratory support, and hospital stay between groups.

**Results**: Neonates receiving surfactant had greater improvement in arterial oxygenation and lower oxygen requirements than controls. The mean duration of mechanical ventilation was shorter in the surfactant group (0.53 ±1.01 versus 1.10 ±1.21 days; $p = 0.042$), as were the durations of continuous positive airway pressure (2.70 ±1.99 versus 3.77 ±0.97 days; $p < 0.001$) and oxygen therapy (4.33 ±2.25 versus 6.73 ±1.34 days; $p < 0.001$). The mean hospital stay was 6.50 ±2.66 days in the surfactant group, compared with 11.83 ±2.21 days in controls ($p < 0.001$).

**Conclusion:** A single surfactant bolus was associated with improved oxygenation, shorter durations of respiratory support, and reduced hospital stay in neonates with MAS. These findings are relevant to neonatal units with limited resources.

**Keywords:** Meconium aspiration syndrome; pulmonary surfactants; newborn; oxygen therapy; mechanical ventilation; hospital stay

## Introduction

Meconium aspiration syndrome (MAS) remains an important cause of respiratory distress and respiratory failure in term and post-term neonates.[1,2] Severity varies, ranging from mild respiratory distress to severe hypoxic respiratory failure requiring mechanical ventilation, high-frequency ventilation, inhaled nitric oxide, and, occasionally, extracorporeal membrane oxygenation (ECMO).[3]

The pathophysiology of MAS is multifactorial. Meconium can cause partial or complete airway obstruction, leading to atelectasis, air trapping, and hyperinflation. Chemical pneumonitis, pulmonary inflammation, and persistent pulmonary hypertension may further aggravate hypoxemia.[3,4] In addition, meconium **inactivates endogenous pulmonary surfactant**, contributing to poor lung compliance and impaired gas exchange. This provides a physiological basis for the use of exogenous surfactant in severe MAS.[5-7]

Surfactant replacement is well established for respiratory distress syndrome of prematurity, but its role in MAS is less clearly defined. In an early randomized controlled trial of 40 ventilated term infants with MAS, Findlay et al. reported improved oxygenation after surfactant administration, along with reductions in pulmonary morbidity and hospitalization duration.[8]

Despite its physiological rationale and potential benefit, evidence on the use of bolus surfactant in MAS remains limited.[9,10] This is particularly relevant in resource-limited settings, where ECMO and other advanced rescue therapies may not be readily available.[3] We therefore evaluated the use of bolus surfactant in neonates with MAS and its effects on respiratory and clinical outcomes.

## METHODS

We conducted this randomized comparative trial in the neonatal intensive care unit (NICU) at Shri Dada Dev Matri Avum Shishu Chikitsalaya, Dabri, New Delhi, from January 2019 to December 2019. The study protocol was approved by the institutional ethics committee before commencement of the study. Written informed consent was obtained from parents before enrolment.

Singleton newborns with a gestational age greater than 34 weeks who were admitted within 24 hours of birth with meconium aspiration syndrome and respiratory distress (Downes score ≥4) were included in the study. Newborns with major congenital malformations, congenital heart disease, sepsis or congenital pneumonia, or severe birth asphyxia were excluded.

Sample size was estimated based on previously reported mean ventilation durations of 2.87 ±1.30 and 6.33 ±4.47 days. With a two-sided significance level of 0.05 and 90% power, approximately 22 newborns per group were required, including a 10% dropout allowance. We planned to enroll 30 newborns per group.

We enrolled 60 newborns and randomly assigned them to two groups of 30 using a computer-generated randomization system. The control group received standard care per the NICU protocol. The intervention group received the same care plus a 5 mL/kg bolus of surfactant (Neosurf). Surfactant was delivered via an endotracheal tube in four equal aliquots. Positive-pressure ventilation was administered for one minute after each aliquot. We closely monitored vital signs, and oxygen saturation remained above 90% throughout the procedure. Arterial oxygen tension ($PaO_2$), inspired oxygen fraction ($FiO_2$), alveolar-arterial oxygen gradient (A-a $DO_2$), respiratory rate, and the Downes score were assessed in both groups at admission and at 24, 48, and 72 hours during follow-up. In the surfactant group, follow-up assessments were timed from surfactant administration. We recorded the duration of mechanical ventilation, continuous positive airway pressure (CPAP), and oxygen therapy, along with the length of hospital stay and days with tachypnea. We recorded clinical findings and blood gas results in a study form. All newborns were followed until discharge. Data were analyzed using SPSS version 17.0. Continuous variables were presented as mean ± standard deviation and as the median, depending on their distribution. Categorical variables were reported as frequencies and percentages. Between-group comparisons were performed using Student's t-test for normally distributed continuous variables and the Mann-Whitney U test for non-normally distributed variables. Categorical variables were compared using the

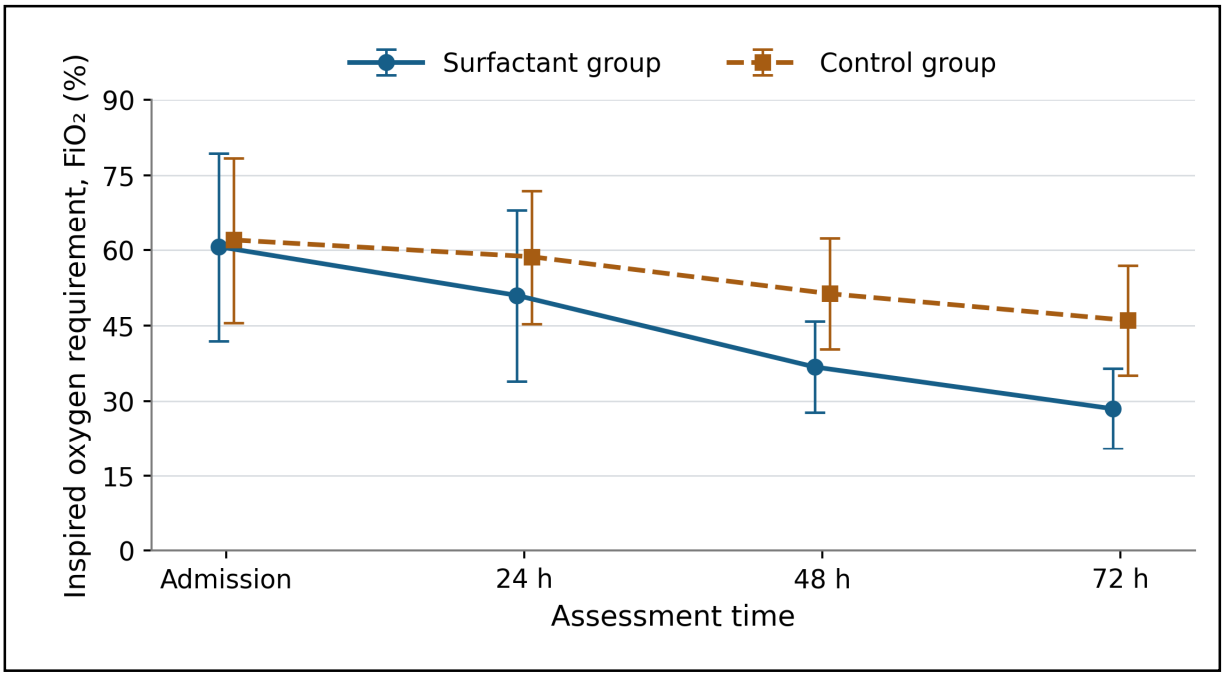
chi-square test. A p-value < 0.05 was considered statistically significant.

## RESULTS

Surfactant was administered at a mean age of 11.27 hours after birth (range, 2-44 hours). At admission, mean $PaO_2$ was similar between the surfactant and control groups (95.73 versus 88.47 mmHg; p = 0.198). At 24 hours, $PaO_2$ was higher in the surfactant group (116.90 versus 102.13 mmHg; p = 0.012) and remained higher at 48 hours (115.57 versus 103.23 mmHg; p = 0.019) and 72 hours (114.93 versus 100.20 mmHg; p = 0.001).

The mean $FiO_2$ requirement was similar at admission (60.67% versus 62.00%; p = 0.771). At 24 hours, the difference was not statistically significant (51.00% versus 58.67%; p = 0.058). $FiO_2$ was lower in the surfactant group at 48 hours (36.77% versus 51.33%) and 72 hours (28.47% versus 46.03%; both p < 0.001).

**Figure 1:** Oxygen requirements at admission and during follow-up




*Points and error bars show means ±standard deviation; n = 30 per group. Between-group p-values: admission, 0.771; 24 h, 0.058; 48 h and 72 h, <0.001.*

In result, the mean alveolar-arterial oxygen gradient was comparable at admission (258.67 versus 276.00 mmHg; p = 0.583). At 24 hours, it was lower in the surfactant group, but the difference was not statistically significant (194.60 versus 242.77 mmHg; p = 0.089). It was significantly lower at 48 hours (105.33 versus 219.93 mmHg) and 72 hours (69.17 versus 183.27 mmHg; both p < 0.001).

Mean Downes scores were similar at admission (6.27 versus 6.53; p = 0.392). Scores decreased over time in both groups and were lower in the surfactant group at 24 hours (5.13 versus 6.10), 48 hours (3.72 versus 5.73), and 72 hours (2.63 versus 5.27; all p < 0.001).

We observed that, the mean duration of mechanical ventilation was shorter in the surfactant group than in the control group (0.53 versus 1.10 days; p = 0.042). Mean durations of CPAP support (2.70 versus 3.77 days) and oxygen therapy (4.33 versus 6.73 days) were also shorter in the surfactant group (both p < 0.001).

**Table 1:** Duration of respiratory support and hospital stay

| Outcome (days) | Surfactant group (n = 30) | Control group (n = 30) | p-value |
|---|---|---|---|
| Mechanical ventilation | 0.53 ± 1.01 | 1.10 ± 1.21 | 0.042 |
| CPAP support | 2.70 ± 1.99 | 3.77 ± 0.97 | <0.001 |
| Oxygen therapy | 4.33 ± 2.25 | 6.73 ± 1.34 | <0.001 |
| Tachypnea | 3.37 ± 1.33 | 6.53 ± 1.61 | <0.001 |
| Hospital stay | 6.50 ± 2.66 | 11.83 ± 2.21 | <0.001 |

*Values are mean ±standard deviation in days. CPAP, continuous positive airway pressure.*

## Discussion

A single surfactant bolus was associated with improved oxygenation, shorter durations of respiratory support, and reduced hospital stay in neonates with MAS. These findings may be particularly relevant to neonatal units with limited resources.

A Cochrane review of four randomized controlled trials involving 326 infants found no significant reduction in mortality with surfactant (risk ratio [RR] 0.98; 95% confidence interval [CI] 0.41-2.39). However, analysis of two trials involving 208 infants showed a significant reduction in the need for ECMO (RR 0.64; 95% CI 0.46-0.91), with a number needed to treat of 6.[9] A subsequent systematic review also reported that bolus surfactant reduced the need for ECMO and was associated with shorter duration of mechanical ventilation and hospital stay, although the available studies were relatively few and included small numbers of neonates.[10]

This was a single-center study involving 60 neonates; the findings should therefore be interpreted cautiously.

## Conclusion

As per the aim of our study, A single bolus of surfactant improved arterial oxygenation, reduced oxygen requirements, and shortened the duration of mechanical ventilation and hospital stay in neonates with meconium aspiration syndrome compared with controls. These findings suggest a potential role for bolus surfactant therapy in reducing the need for prolonged respiratory support, which may be particularly relevant in settings with limited neonatal intensive care resources.

## Declarations

**Ethical Approval:** The study protocol was approved by the Institutional Ethics Committee of Shri Dada Dev Matri Avum Shishu Chikitsalaya, New Delhi, before commencement of the study. Written informed consent was obtained from the parents of all participating neonates.

### Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to applicable institutional and ethical requirements.

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**Conflict of interest:** The authors declare that they have no competing interests.

**Use of Artificial Intelligence**

The authors used AI-assisted tools solely for grammatical correction, language refinement, and improving the readability of the manuscript. No AI tools were used to generate research data, analyse results, interpret findings, or draw scientific conclusions. The authors take full responsibility for the accuracy, originality, and integrity of the manuscript.

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