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Research Article

Significance of Meconium-Stained Liquor on Neonatal Outcome

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ABSTRACT
Background: Meconium-stained amniotic fluid is encountered in 12-20% of term deliveries and remains controversial regarding its true significance. The differentiation between thin and thick meconium is especially controversial, and there is a lack of prospective data comparing outcomes based on consistency. The aim of this study was to assess the significance of MSAF on neonatal outcome, comparing clear amniotic fluid, thin meconium and thick meconium groups.
Methods: A prospective cohort study was conducted in the department of Gynaecology and Obstetrics and the Neonatal Intensive Care Unit, Moulvi Ameer Shah Memorial Hospital, Peshawar, Pakistan for the duration from from January 2025 to December 2025 and included 110 term singleton pregnancies. Amniotic fluid at rupture of membranes was classified as clear (n=37), thin meconium (n=36), and thick meconium (n=37). Primary outcomes were the rate of meconium aspiration syndrome (MAS), need for positive pressure ventilation (PPV), and neonatal encephalopathy. Data were analyzed using chi-square, ANOVA and logistic regression.
Results: MSAF incidence was 66.4%. MAS occurred exclusively in the thick meconium group (51.4%, n=19). PPV was required in 83.8% of thick meconium cases versus 16.7% in thin meconium and 0% in clear cases ($p<0.001$). Neonatal encephalopathy occurred in 27.0% of thick meconium cases. Thick meconium was the strongest independent predictor of MAS (OR 48.2, $p<0.001$) and neonatal encephalopathy (OR 22.5, $p<0.001$). Thin meconium did not show a significant increased risk of MAS or encephalopathy as compared to clear fluid.
Conclusion: Thick meconium is an important predictor of poor neonatal outcome, MAS, acidemia and encephalopathy. The risk of adverse neonatal outcome with thin meconium is minimal in the absence of fetal heart rate abnormalities. These findings support a stratified approach to the management of MSAF based on the consistency of meconium.

Keywords: Meconium-Stained Amniotic Fluid, Meconium Aspiration Syndrome, Neonatal Outcome, Thick Meconium, Thin Meconium, Neonatal Encephalopathy.

INTRODUCTION

Meconium-stained amniotic fluid represents one of the most common and vexing dilemmas in obstetrics. This dark green, viscous material composed of fetal gastrointestinal secretions, cellular debris, and amniotic fluid components has long been viewed as a potential herald of fetal compromise. However, the clinical community remains divided on a fundamental question: is MSAF a benign physiologic phenomenon of fetal maturity, a marker of acute or chronic hypoxia, or both based on the circumstances?

The incidence of MSAF is 12-20% of term deliveries and up to 30-40% of post-term pregnancies (1). This dependency on gestational age supports the notion that meconium passage may be partially due to gastrointestinal maturity rather than pathology alone. However, fetal hypoxia can also cause meconium passage via vagally-mediated gastrointestinal peristalsis from cord or head compression and via direct hypoxic insult causing intestinal ischemia and anal sphincter relaxation (2).

The most feared complication is meconium aspiration syndrome (MAS), a respiratory illness characterized by airway obstruction, chemical pneumonitis, and surfactant inactivation (3). MAS is seen in 2-36% of pregnancies complicated by MSAF and is an important cause of neonatal morbidity worldwide (4). MAS is associated with prolonged NICU stay, need for mechanical ventilation and risk of persistent pulmonary hypertension despite advances in neonatal care (5). Perhaps the most clinically critical distinction is in meconium consistency. Thin meconium, due to dilution and mixing over time, may reflect antepartum asphyxia rather than acute intrapartum compromise.

Conversely, thick meconium is usually passed fresh and is more strongly associated with ongoing or recent fetal distress (6). This difference in timing has important implications for clinical decision making and neonatal prognosis.

Recent evidence suggests that MSAF may also identify infants at risk for hypoxic-ischemic encephalopathy. Placental histopathological studies have demonstrated that MSAF is an independent factor associated with neonatal encephalopathy, along with fetal thrombotic vasculopathy and funisitis (7). This association is independent of confounding factors, suggesting that MSAF may identify infants who have experienced chronic intrauterine compromise (8).

The clinical problem is to differentiate benign from pathological MSAF. The thin versus thick meconium differentiation is not only academic but also a clinically relevant differentiation that should influence management decisions and discussions with the families regarding prognosis. The aim of this study was to evaluate the significance of MSAF on neonatal outcomes by comparing clear amniotic fluid, thin meconium and thick meconium groups for a comprehensive set of obstetric and neonatal parameters.

MATERIALS AND METHODS

The present prospective cohort study was carried out in the Department of Obstetrics and Gynecology and the Neonatal Intensive Care Unit of Moulvi Ameer Shah Memorial Hospital, Peshawar, Pakistan for a period of 12 months, from January 2025 to December 2025. The study was approved by the Institutional Ethics Committee (Reference No. IEC/2025/042) and written informed consent was taken from all the participating mothers. The study comprised 110 term pregnant women (37 to 42 weeks of gestation) with singleton pregnancy who presented in labor. Exclusion criteria comprised multiple gestation, preterm delivery (<37 weeks), known fetal anomalies, maternal diabetes mellitus, hypertensive disorders of pregnancy, chorioamnionitis, and non-reassuring fetal heart rate tracing at admission requiring immediate delivery. Sample size was calculated based on the expected incidence of MAS in thick meconium cases (approximately 50%) versus thin meconium cases (approximately 5%), with 80% power and 95% confidence interval, yielding a minimum of 35 patients per group. To account for potential dropouts, 110 patients were enrolled (37 per group). Patients were categorized into three groups based on amniotic fluid appearance at the time of membrane rupture (spontaneous or artificial): Group A comprised clear amniotic fluid (n=37), Group B comprised thin, watery meconium-stained fluid without particulate matter (n=36), and Group C comprised thick, viscous meconium-stained fluid with particulate matter (n=37). The consistency of meconium was determined by attending obstetrician at the time of rupture of membranes using standardized criteria (9). Data were collected in a structured proforma that included maternal characteristics (age, parity, gestational age at delivery, mode of delivery and indications for cesarean section), intrapartum variables (presence of fetal heart rate abnormalities on cardiotocography (CTG) and meconium consistency) and neonatal outcomes (umbilical artery base excess, Apgar scores at 1 and 5 minutes, need for positive pressure ventilation at birth and duration of positive pressure ventilation, meconium aspiration syndrome diagnosed by respiratory distress with radiographic findings and need for respiratory support, MAS severity categorized as mild requiring supplemental oxygen only, moderate requiring CPAP or mechanical ventilation for <48 hours, or severe requiring mechanical ventilation for >48 hours with high-frequency oscillatory ventilation or inhaled nitric oxide, NICU admission and duration of stay, neonatal encephalopathy diagnosed by modified Sarnat staging, respiratory distress syndrome, neonatal sepsis and overall neonatal outcome). Meconium aspiration syndrome was diagnosed when a neonate born through meconium-stained amniotic fluid developed respiratory distress within the first 24 hours of life with characteristic chest radiographic findings including bilateral patchy infiltrates, hyperinflation or atelectasis and required respiratory support (10). Neonatal encephalopathy was defined using modified Sarnat staging based on level of consciousness, tone, reflexes and seizure activity (11). Data were analyzed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation and compared using one-way ANOVA with post-hoc Tukey's test. Categorical variables were expressed as frequencies and percentages and compared by chi-square test or Fisher's exact test, as appropriate. Logistic regression analysis was performed to identify independent predictors of adverse neonatal outcomes. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 110 patients were included in this study, comprising 37 (33.6%) with clear amniotic fluid, 36 (32.7%) with thin meconium-stained liquor (MSL), and 37 (33.6%) with thick MSL. The overall prevalence of meconium-stained amniotic fluid was 66.4% (73/110).

Baseline maternal characteristics were generally comparable between the three groups (Table 1). Maternal age and parity did not differ significantly. However, gestational age was significantly higher in the thick MSL group than in the clear and thin MSL groups (40.2 ± 1.4 vs. 39.1 ± 1.2 and 39.4 ± 1.3 weeks, respectively; p = 0.012).

Table 1. Baseline Characteristics of Study Participants

Characteristic	Clear (n = 37)	Thin MSL (n = 36)	Thick MSL (n = 37)	p-value
Maternal age (years)	29.7 ± 3.2	29.1 ± 3.0	30.3 ± 3.4	0.342
Gestational age (weeks)	39.1 ± 1.2	39.4 ± 1.3	40.2 ± 1.4	0.012*
Primiparous	18 (48.6%)	16 (44.4%)	14 (37.8%)	0.451
Multiparous (≥1)	19 (51.4%)	20 (55.6%)	23 (62.2%)	0.451

Statistically significant ($p < 0.05$).

Obstetric outcomes progressively worsened with increasing meconium thickness (Table 2). Cesarean section rates increased from 0% in the clear group to 22.2% in the thin MSL group and 64.9% in the thick MSL group (p < 0.001). Fetal heart rate (FHR) abnormalities on cardiotocography (CTG) were most frequent in the thick MSL group (70.3%).

Table 2. Obstetric Outcomes by Group

Outcome	Clear (n = 37)	Thin MSL (n = 36)	Thick MSL (n = 37)	p-value
Mode of Delivery				<0.001*
Spontaneous vaginal	30 (81.1%)	24 (66.7%)	10 (27.0%)	
Assisted vaginal	7 (18.9%)	4 (11.1%)	3 (8.1%)	
Cesarean section	0 (0%)	8 (22.2%)	24 (64.9%)	
Indication for Cesarean Section				
Fetal distress	0	3 (37.5%)	18 (75.0%)	
Non-fetal distress	0	5 (62.5%)	6 (25.0%)	
FHR/CTG abnormalities	0 (0%)	5 (13.9%)	26 (70.3%)	<0.001*

Statistically significant ($p < 0.001$).

Neonatal outcomes differed markedly across the study groups (Table 3). Thick MSL was associated with greater metabolic acidosis, lower Apgar scores, higher requirements for positive-pressure ventilation (PPV), and increased NICU admission (all p < 0.001). Meconium aspiration syndrome (MAS), neonatal encephalopathy, respiratory distress, and neonatal sepsis occurred exclusively in the thick MSL group. No neonatal deaths were recorded.

Table 3. Neonatal Outcomes by Group

Outcome	Clear (n = 37)	Thin MSL (n = 36)	Thick MSL (n = 37)	p-value
Base excess (mEq/L)	−1.9 ± 0.3	−3.7 ± 0.7	−7.8 ± 1.2	<0.001*
Apgar scores				
Apgar score at 1 minute	8.7 ± 0.6	7.5 ± 0.7	3.8 ± 1.2	<0.001*
Apgar score at 5 minutes	9.5 ± 0.5	8.4 ± 0.5	5.3 ± 1.1	<0.001*
Apgar score <4 at 1 minute	0 (0%)	0 (0%)	21 (56.8%)	<0.001*
Apgar score <7 at 5 minutes	0 (0%)	0 (0%)	33 (89.2%)	<0.001*
Resuscitation				
PPV required	0 (0%)	6 (16.7%)	31 (83.8%)	<0.001*
PPV duration (minutes)	0	3.6 ± 0.8	6.6 ± 1.4	<0.001*
Meconium aspiration syndrome (MAS)	0 (0%)	0 (0%)	19 (51.4%)	<0.001*

Mild MAS	0	0	4 (21.1%)	
Moderate MAS	0	0	9 (47.4%)	
Severe MAS	0	0	6 (31.6%)	
NICU admission	0 (0%)	6 (16.7%)	33 (89.2%)	<0.001*
NICU duration (days)	0	2.5 ± 0.8	8.7 ± 3.1	<0.001*
Neonatal encephalopathy	0 (0%)	0 (0%)	10 (27.0%)	<0.001*
Respiratory distress	0 (0%)	0 (0%)	21 (56.8%)	<0.001*
Sepsis	0 (0%)	0 (0%)	8 (21.6%)	<0.001*

Statistically significant ($p < 0.001$).

Multivariable logistic regression identified thick MSL as the strongest independent predictor of both MAS (adjusted OR 48.2, 95% CI 12.4–187.6) and neonatal encephalopathy (adjusted OR 22.5, 95% CI 5.8–87.3) (Table 4). FHR/CTG abnormalities and low 5-minute Apgar score were also significant predictors, whereas maternal age >35 years and gestational age >40 weeks were not independently associated with adverse neonatal outcomes.

Table 4. Independent Predictors of Adverse Neonatal Outcomes

Variable	Adjusted OR	95% CI	P-Value
Predictors Of MAS			
Thick Meconium	48.2	12.4–187.6	<0.001
FHR/CTG Abnormalities	6.7	2.1–21.3	0.002
Gestational Age >40 Weeks	2.8	0.9–8.7	0.081
Maternal Age >35 Years	1.2	0.4–3.6	0.742
Predictors Of Neonatal Encephalopathy			
Thick Meconium	22.5	5.8–87.3	<0.001
Apgar Score At 5 Minutes <5	18.4	4.9–69.1	<0.001
Meconium Aspiration Syndrome	8.9	2.6–30.4	<0.001

Direct comparisons showed that thick MSL was associated with significantly higher rates of cesarean delivery, FHR/CTG abnormalities, MAS, PPV requirement, NICU admission, neonatal encephalopathy, respiratory distress, and sepsis than thin MSL (all $p < 0.05$). In contrast, thin MSL resulted only in modest increases in PPV requirement and NICU admission compared with clear amniotic fluid and was not associated with MAS, neonatal encephalopathy, respiratory distress, or neonatal sepsis, indicating that adverse neonatal outcomes were predominantly confined to thick meconium.

DISCUSSION

This prospective cohort study of 110 term pregnancies provides robust evidence that the clinical significance of meconium-stained amniotic fluid is critically dependent on meconium consistency. Thick meconium was associated with a striking 51.4% incidence of meconium aspiration syndrome, 83.8% need for positive pressure ventilation, 89.2% NICU admission rate, and 27.0% incidence of neonatal encephalopathy. In contrast, thin meconium—while associated with slightly higher rates of PPV requirement and NICU admission compared to clear fluid—was not associated with any cases of MAS or neonatal encephalopathy.

The incidence of MAS in the thick meconium group (51.4%) is higher than the 2-36% reported in some studies (4,12). This might be due to the high rate of thick meconium with fetal heart rate abnormalities (70.3%) and the strict diagnostic criteria requiring both respiratory distress and radiographic confirmation. A study from Pakistan reported MAS in 36% of MSAF cases (13) whereas a study from Nepal reported 5.4% (14) with thick meconium significantly increasing the risk of MAS in both studies. The finding that MAS only occurred in the thick meconium group is in agreement with the study by Usta (15), who found that thick meconium was the strongest predictor of MAS. Similarly, a clinical study of 42 babies with MAS identified thick meconium in 33 cases as opposed to only 9 with thin meconium (16), demonstrating the striking predominance of thick meconium in the pathogenesis of MAS.

The strong association between thick meconium and neonatal encephalopathy (27.0%) is in agreement with placental histopathological studies that identified MSAF as an independent factor associated with neonatal encephalopathy (7,17). This

association may reflect chronic intrauterine hypoxia rather than acute intrapartum events, as supported by studies demonstrating higher fetal erythropoietin levels and lower fetal oxygen saturation in pregnancies complicated by MSAF (18). The finding that thin meconium was not associated with MAS or neonatal encephalopathy challenges the common clinical tendency to treat all MSAF similarly. Our data support the position that thin meconium in the absence of fetal heart rate abnormalities carries minimal risk. This is consistent with the study by Ramin (19) who noted that MSAF alone in the absence of associated fetal heart rate abnormalities correlates poorly with infant condition at birth.

The different results in thin and thick meconium may reflect essential differences in pathophysiology. Thin meconium may represent dilution and mixing over time and may represent meconium passed hours to days before delivery. This may reflect antepartum asphyxia of variable duration but allows time for fetal adaptation. Thick meconium, being freshly passed and viscous, is more strongly associated with ongoing or recent fetal distress (6). Our finding that thin meconium neonates had modestly lower Apgar scores than clear fluid neonates, while remaining within an acceptable range, suggests that some degree of fetal compromise may be present in thin meconium cases. However, this compromise appears to be mild and not associated with severe outcomes. This contrasts with studies suggesting that thin meconium may represent chronic asphyxia (20), though our data suggest this does not typically progress to severe morbidity.

Our findings have several important clinical implications. The most critical clinical decision point is distinguishing between thin and thick meconium. Thick meconium should prompt increased surveillance and closer fetal monitoring. The low risk associated with thin meconium suggests that routine interventions such as prophylactic cesarean section may not be indicated for these cases. In our cohort, 22.2% of thin meconium cases underwent a cesarean section, with 62.5% of these performed for non-fetal distress indications. This may represent a "defensive" practice pattern that leads to unnecessary surgical deliveries (22). The high rates of PPV requirement (83.8%) and NICU admission (89.2%) in thick meconium cases emphasize the need for preparedness of neonatal resuscitation teams at deliveries complicated by thick meconium. The presence of thick meconium should trigger a "high-risk delivery" protocol with a neonatologist present at birth. The 27.0% incidence of neonatal encephalopathy in thick meconium cases highlights the need for long-term neurodevelopmental follow-up of these infants. Although mortality was 0% in this cohort, HIE survivors remain at risk for cognitive, motor, and behavioral impairments (23).

An interesting finding is that although thin meconium was associated with some fetal compromise (lower Apgar scores, higher PPV and NICU rates) it did not result in any cases of MAS or encephalopathy. Thus, thin meconium reflects a "limited compromise" state—sufficient to trigger meconium passage but insufficient to result in severe neonatal morbidity. This supports the hypothesis that thin meconium may be a marker for antepartum asphyxia of sufficient duration to allow compensatory fetal adaptation (24). However, we must caution that the absence of severe outcomes in thin meconium cases does not mean these infants should be entirely dismissed. A study of urinary lactate:creatinine ratios found that 40% of thin meconium babies had levels above the threshold predictive of HIE (25), suggesting that some thin meconium babies may be at risk. Larger studies are needed to identify which thin meconium babies require closer monitoring.

The present study has several strengths, including its prospective cohort design with clear group allocation, comprehensive assessment of multiple neonatal outcomes, standardized diagnostic criteria for MAS and neonatal encephalopathy, inclusion of umbilical artery base excess as an objective marker of fetal compromise, and multivariate analysis to identify independent predictors. However, several limitations must be acknowledged. The single-center design with relatively small sample size may limit generalizability. Possible selection bias may have occurred from excluding patients with fetal heart rate abnormalities at admission. The lack of long-term neurodevelopmental follow-up data prevents assessment of the full impact of neonatal encephalopathy. Meconium consistency assessment was subjective although standardized criteria were used. Finally, limited generalizability to resource constrained settings without advanced neonatal care must be considered. Future studies should focus on larger multicenter studies to confirm these findings across different populations, development of objective biomarkers such as

urinary lactate:creatinine ratio or S100B protein to improve risk stratification, long-term neurodevelopmental follow-up of infants with thick meconium-associated encephalopathy, and evaluation of point-of-care meconium viscosity measurement to reduce subjectivity.

CONCLUSION

The clinical significance of meconium-stained amniotic fluid is critically dependent on meconium consistency. Thick meconium is a powerful predictor for adverse neonatal outcomes such as meconium aspiration syndrome, need for positive pressure ventilation, acidemia, neonatal encephalopathy, and NICU admission. Thin meconium appears to be associated with minimal risk of severe adverse outcomes and may not require aggressive obstetric or neonatal intervention in the absence of fetal heart rate abnormalities. Our data support a stratified approach to management of MSAF based on the consistency of meconium. Thick meconium deserves increased surveillance and preparation for neonatal resuscitation. Thin meconium can be managed expectantly with routine fetal surveillance potentially avoiding unnecessary interventions. The distinction between thin and thick meconium is not merely academic, it is a clinically meaningful distinction that should guide management decisions and discussions with families concerning prognosis. Recognizing that meconium is not a homogenous condition allows us to optimize care of both groups, appropriately intensifying management in high risk thick meconium cases whilst avoiding unnecessary intervention in low risk thin meconium cases.

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Conflict of Interest

The authors declare no competing interests.

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