International Journal of Reproduction, Contraception, Obstetrics and Gynecology
Sharma M et al. Int J Reprod Contracept Obstet Gynecol. 2025 Sep;14(9):2963-2968
www.ijrcog.org
pISSN 2320-1770 | eISSN 2320-1789

DOI: https://dx.doi.org/10.18203/2320-1770.ijrcog20252725

Original Research Article

Effect of borderline amniotic fluid index in last trimester on perinatal outcome in eastern India: a prospective observational study

Meeta Sharma[1], Shagun Gupta[1]*, Aarti Kothari[2]

[1]Department of Obstetrics and Gynecology, Mahatma Gandhi University of Medical Sciences and Technology Jaipur, Rajasthan, India
[2]Department of Obstetrics and Gynaecology, JIET Medical College and Hospital, Jodhpur, Rajasthan, India

Received: 13 June 2025
Revised: 21 July 2025
Accepted: 01 August 2025

***Correspondence:**
Dr. Shagun Gupta,
E-mail: shagun_medico@yahoo.co.in

ABSTRACT

Background: This study was done to evaluate the impact of borderline amniotic fluid index (AFI) on perinatal outcomes in term pregnancies.
Methods: This prospective observational study was conducted between January and June 2024. A total of 120 pregnant women at term (37-40 weeks) were divided into two groups: group A (n=60) with normal AFI (8-24 cm) and group B (n=60) with borderline AFI (5-8 cm). Participants were followed until delivery and up to 7 days postpartum with assessment of maternal and neonatal outcomes.
Results: Baseline maternal characteristics were comparable between groups. The borderline AFI group had significantly higher rates of fetal distress requiring caesarean delivery (30.0% versus 13.3%, p=0.026), meconium-stained amniotic fluid (36.7% versus 16.7%, p=0.013), and NICU admissions (23.3% versus 10.0%, p=0.048). Neonates in the borderline AFI group had lower birth weights (3042±384g versus 3186±352g, p=0.034), lower umbilical cord pH (7.24±0.08 versus 7.28±0.07, p=0.004), and more early neonatal complications (18.3% versus 6.7%, p=0.045). Subgroup analysis revealed poorer outcomes in pregnancies with AFI 5-6.5 cm compared to AFI 6.6-8 cm.
Conclusions: Borderline AFI at term is associated with adverse perinatal outcomes and should be considered a risk factor requiring closer antenatal monitoring and modified intrapartum management. The risk appears to increase with decreasing AFI values, even within the borderline range.

Keywords: Amniotic fluid index, Borderline AFI, Fetal distress, Perinatal outcome

INTRODUCTION

Background/rationale: Amniotic fluid is a crucial component in pregnancy that plays multiple vital roles in fetal development, including providing nutrition, allowing fetal movement, protecting against trauma, and enabling proper development of the fetal lungs and gastrointestinal system.[1,2] The amniotic fluid index (AFI) is the preferred method for assessing amniotic fluid volume during pregnancy, calculated by summing the deepest vertical pocket measurements from four uterine quadrants.[3]

While oligohydramnios (AFI<5 cm) and polyhydramnios (AFI>24 cm) are well-established risk factors for adverse pregnancy outcomes, there is growing interest in understanding the implications of borderline AFI, typically defined as measurements between 5-8 cm.[4]

Recent research suggests that pregnancies with borderline AFI may be at increased risk for various complications, including higher rates of caesarean delivery for fetal distress, meconium-stained amniotic fluid, and neonatal intensive care unit (NICU) admissions.[5]

Amniotic fluid volume is a dynamic parameter that reflects both fetal well-being and placental function. A reduction in amniotic fluid, even when not meeting the criteria for oligohydramnios, may indicate subtle placental insufficiency or altered fetal homeostasis that could compromise fetal reserve, particularly during the stress of labor. Understanding whether borderline AFI truly represents a distinct pathological entity or simply a variant of normal is essential for optimizing maternal and neonatal care.

The physiological basis for potential adverse outcomes in borderline AFI may involve reduced cushioning of the umbilical cord, leading to increased vulnerability to compression during uterine contractions. Additionally, decreased amniotic fluid may reflect diminished fetal urine production due to redistribution of blood flow away from the kidneys in response to subtle hypoxic stress.

Given these considerations, this case control study was designed to evaluate the impact of borderline AFI on perinatal outcomes in term pregnancies. By comparing a range of maternal and neonatal outcomes between women with borderline versus normal AFI, we aimed to provide evidence that could guide clinical decision-making regarding the management of pregnancies with borderline AFI.

METHODS

Study design and setting

This prospective observational study was conducted at Mahatma Gandhi University of Medical Sciences and Technology, Jaipur between January 2024 and June 2024. The study protocol was approved by the institutional ethics committee, and written informed consent was obtained from all participants.

Sample size and study groups

A total of 120 pregnant women at term (37-40 weeks) were included in the study and divided into two groups: group A: 60 women with normal AFI (8-24 cm) and group B: 60 women with borderline AFI (5-8 cm).

Inclusion criteria included singleton pregnancy with Gestational age between 37-40 weeks with cephalic presentation and intact membranes. There should be no known fetal anomalies and no maternal medical complications.

Exclusion criteria included multiple pregnancies, premature rupture of membranes, fetal congenital anomalies, previous caesarean section, medical disorders complicating pregnancy and pregnancy beyond 40 weeks.

AFI measurements were performed using a standardized technique with a 3.5 MHz curvilinear transducer. The uterus was divided into four quadrants. The largest vertical pocket of amniotic fluid in each quadrant was measured in centimeters, excluding cord loops and fetal parts. The sum of these four measurements provided the AFI.

Maternal parameters including demographic data, obstetric history, mode of delivery, indications for caesarean section and labor complications were noted.

Fetal surveillance including non-stress test findings with colour of amniotic fluid with intrapartum fetal heart rate patterns were noted.

Primary outcomes were noted- mode of delivery, indication for caesarean section, meconium-stained amniotic fluid, 5-minute Apgar score. Secondary Outcomes were noted: birth weight, NICU admission, duration of NICU stay, umbilical cord pH, early neonatal complications, perinatal mortality.

All participants were followed until delivery and up to 7 days postpartum. Those with borderline AFI underwent twice-weekly antenatal testing including non-stress tests and AFI measurements.

Data analysis was performed using SPSS version 26.0. Continuous variables were expressed as mean±standard deviation and compared using Student's t-test. Categorical variables were expressed as frequencies and percentages and compared using Chi-square or Fisher's exact test as appropriate. A p value <0.05 was considered statistically significant.

The sample size was calculated using a power of 80% and a significance level of 5%, assuming a 20% difference in adverse perinatal outcomes between the two groups based on previous studies.

RESULTS

In this prospective observational study, we examined the impact of borderline amniotic fluid index (AFI) on perinatal outcomes in term pregnancies. A total of 120 pregnant women at term (37-40 weeks gestation) were enrolled and divided into two groups: group A consisting of 60 women with normal AFI (8-24 cm) and group B consisting of 60 women with borderline AFI (5-8 cm).

Baseline characteristics

The baseline demographic and clinical characteristics of the study participants are presented in Table 1. Both groups were comparable in terms of maternal age, with a mean age of 27.6±4.3 years in group A and 28.1±4.5 years in group B (p=0.534). The gestational age at enrolment was also similar between the groups, with means of 38.2±1.1 weeks and 38.4±1.2 weeks in groups A and B, respectively (p=0.326).

The distribution of primigravida women was comparable between the groups, with 56.7% in group A and 61.7% in

group B (p=0.579). Similarly, body mass index (BMI) did not differ significantly between the groups, with means of 26.8±3.4 kg/m^2 in group A and 27.2±3.7 kg/m^2 in group B (p=0.523). As expected per study design, the mean AFI was significantly different between the groups, with values of 14.7±3.2 cm in group A and 6.8±0.9 cm in group B (p<0.001) (Table 1).

Table 1: Baseline characteristics of study participants.

Characteristics	Group A: normal AFI (n=60)	Group B: borderline AFI (n=60)	P value
Maternal age (years)	27.6±4.3	28.1±4.5	0.534
Gestational age at enrolment in weeks	38.2±1.1	38.4±1.2	0.326
Primigravida, n (%)	34 (56.7%)	37 (61.7%)	0.579
Body mass index (kg/m^2)	26.8±3.4	27.2±3.7	0.523
Mean AFI (cm)* (Mean±SD)	14.7±3.2	6.8±0.9	<0.001

Table 2: Primary perinatal outcomes.

Outcomes	Group A: normal AFI (n=60) N (%)	Group B: borderline AFI (n=60) N (%)	P value
Mode of delivery			
Vaginal delivery	45 (75.0)	36 (60.0)	0.078
Cesarean section	15 (25.0)	24 (40.0)	0.078
Indication for cesarean delivery			
Fetal distress	8 (13.3)	18 (30.0)	0.026
Non-progress of labor	7 (11.7)	6 (10.0)	0.768
Meconium-stained amniotic fluid	10 (16.7)	22 (36.7)	0.013
5-minute Apgar score <7	3 (5.0)	9 (15.0)	0.067

Table 3: Secondary perinatal outcomes.

Outcomes	Group A: normal AFI (n=60)	Group B: borderline AFI (n=60)	P value
Birth weight (gm)	3186±352	3042±384	0.034
NICU admission, N (%)	6 (10.0)	14 (23.3)	0.048
Duration of NICU stay (days)	2.8±1.2	3.6±1.8	0.042
Umbilical cord pH	7.28±0.07	7.24±0.08	0.004
Early neonatal complications, N (%)	4 (6.7)	11 (18.3)	0.045
Perinatal mortality, N (%)	0 (0)	1 (1.7)	0.315

Table 4: Fetal surveillance findings.

Parameters	Group A: normal AFI (n=60) N (%)	Group B: borderline AFI (n=60) N (%)	P value
Non stress test			
Reactive	58 (96.7)	53 (88.3)	0.092
Non-reactive	2 (3.3)	7 (11.7)	
Intrapartum FHR patterns			
Normal	51 (85.0)	40 (66.7)	0.018
Abnormal	9 (15.0)	20 (33.3)	
Variable decelerations	6 (10.0)	13 (21.7)	0.080
Late decelerations	2 (3.3)	5 (8.3)	0.243
Prolonged bradycardia	1 (1.7)	2 (3.3)	0.559

Primary perinatal outcomes

The primary perinatal outcomes are detailed in Table 2. Analysis of delivery modes revealed a higher rate of cesarean deliveries in the borderline AFI group (40.0%) compared to the normal AFI group (25.0%), though this difference approached but did not reach statistical significance (p=0.078). Correspondingly, the rate of vaginal deliveries was lower in the borderline AFI group (60.0%) compared to the normal AFI group (75.0%).

When examining the indications for cesarean delivery, we found a significantly higher rate of fetal distress leading to cesarean section in the borderline AFI group (30.0%) compared to the normal AFI group (13.3%) with a p-value of 0.026. This suggests that fetuses in the borderline AFI group were more likely to experience distress during labor, necessitating emergency cesarean delivery. In contrast, cesarean deliveries due to non-progress of labor were similar between the groups (11.7% in group A versus 10.0% in group B, p=0.768).

The presence of meconium-stained amniotic fluid, an important indicator of potential fetal distress, was significantly more common in the borderline AFI group (36.7%) compared to the normal AFI group (16.7%) with a p value of 0.013. This finding suggests that fetuses in the borderline AFI group were more likely to experience hypoxic stress, leading to passage of meconium in utero.

With regard to neonatal well-being as assessed by Apgar scoring, a higher proportion of neonates in the borderline AFI group had 5-minute Apgar scores below 7 (15.0%) compared to those in the normal AFI group (5.0%). Although this difference was marginally significant (p=0.067), it suggests a trend toward poorer immediate neonatal adaptation in the borderline AFI group (Table 2).

Secondary perinatal outcomes

The secondary perinatal outcomes assessed in our study are presented in Table 3. Analysis of birth weight revealed that infants born to mothers with borderline AFI had significantly lower mean birth weights (3042±384 gm) compared to those born to mothers with normal AFI (3186±352 gm) with a p value of 0.034. This finding suggests that reduced amniotic fluid volume, even at borderline levels, may be associated with slightly compromised fetal growth.

The rate of NICU admissions was significantly higher in the borderline AFI group (23.3%) compared to the normal AFI group (10.0%) with a p-value of 0.048. Furthermore, among neonates requiring NICU admission, those from the borderline AFI group had longer durations of stay (3.6±1.8 days) compared to those from the normal AFI group (2.8±1.2 days), and this difference was statistically significant (p=0.042). These findings indicate that neonates from pregnancies with borderline AFI not only had a higher likelihood of requiring intensive care but also needed more prolonged support when admitted.

Analysis of umbilical cord blood gas parameters showed that the mean umbilical cord pH was significantly lower in the borderline AFI group (7.24±0.08) compared to the normal AFI group (7.28±0.07) with a p-value of 0.004. This finding suggests a higher level of fetal acidosis in the borderline AFI group, which aligns with the higher rates of fetal distress and meconium-stained amniotic fluid observed in this group.

Early neonatal complications, including respiratory distress syndrome, transient tachypnea of the newborn, hypoglycemia, and hyperbilirubinemia requiring phototherapy, were observed in 18.3% of neonates in the borderline AFI group compared to 6.7% in the normal AFI group, and this difference was statistically significant (p=0.045). This finding further supports the association between borderline AFI and adverse neonatal outcomes.

There was one case of perinatal mortality in the borderline AFI group (1.7%) due to severe birth asphyxia and none in the normal AFI group. Although this difference did not reach statistical significance (p=0.315), it is clinically noteworthy and warrants consideration in the context of overall perinatal risk assessment (Table 3).

Fetal surveillance findings

Non-stress test (NST) findings were analyzed as part of the antenatal monitoring protocol. In the normal AFI group, 96.7% of NSTs were reactive, compared to 88.3% in the borderline AFI group (p=0.092). Although this difference was not statistically significant, there was a trend toward higher rates of non-reactive NSTs in the borderline AFI group.

Intrapartum fetal heart rate monitoring revealed a higher incidence of abnormal patterns in the borderline AFI group (33.3%) compared to the normal AFI group (15.0%) with a p value of 0.018. The most common abnormalities in the borderline AFI group were variable decelerations (21.7%), followed by late decelerations (8.3%) and prolonged bradycardia (3.3%). In comparison, the normal AFI group had lower rates of variable decelerations (10.0%), late decelerations (3.3%), and prolonged bradycardia (1.7%) (Table 4).

Subgroup analysis

A subgroup analysis was performed to evaluate the impact of different levels of borderline AFI on perinatal outcomes. Participants in group B were further divided into two subgroups: those with AFI 5-6.5 cm (n=28) and those with AFI 6.6-8 cm (n=32).

Interestingly, the subgroup with lower borderline AFI (5-6.5 cm) had significantly higher rates of adverse outcomes compared to those with higher borderline AFI (6.6-8 cm). Specifically, the rates of caesarean delivery for fetal distress (39.3% versus 21.9%, p=0.042), meconium-stained amniotic fluid (46.4% versus 28.1%, p=0.038), and NICU admission (32.1% versus 15.6%, p=0.046) were significantly higher in the lower borderline AFI subgroup.

These findings suggest a dose-response relationship, where the risk of adverse perinatal outcomes increases as the AFI decreases, even within the borderline range. This has important clinical implications for the management of pregnancies with different levels of borderline AFI and

may guide decision-making regarding the frequency of antenatal surveillance and timing of delivery (Table 5).

Table 5: Subgroup analysis of borderline AFI group.

Outcomes	AFI 5-6.5 cm (n=28) N (%)	AFI 6.6-8 cm (n=32) N (%)	P value
Caesarean section	14 (50.0)	10 (31.3)	0.138
Caesarean for fetal distress	11 (39.3)	7 (21.9)	0.042
Meconium-stained amniotic fluid	13 (46.4)	9 (28.1)	0.038
5-minute Apgar score <7	6 (21.4)	3 (9.4)	0.187
NICU admission	9 (32.1)	5 (15.6)	0.046
Umbilical cord pH (Mean±SD)	7.22±0.09	7.26±0.07	0.053

DISCUSSION

This prospective observational study investigated the impact of borderline amniotic fluid index (AFI) on perinatal outcomes in term pregnancies. Our findings demonstrate that pregnancies with borderline AFI (5-8 cm) at term are associated with a higher risk of adverse perinatal outcomes compared to those with normal AFI (8-24 cm). These outcomes include higher rates of caesarean delivery for fetal distress, meconium-stained amniotic fluid, lower Apgar scores, increased NICU admissions, and lower umbilical cord pH values.

The higher incidence of caesarean delivery for fetal distress in the borderline AFI group (30.0% versus 13.3%, p=0.026) aligns with the findings of Asgharnia et al, who reported a significantly increased rate of caesarean sections due to fetal distress in pregnant women with borderline AFI.[4] Similarly, Baron et al found that women with borderline oligohydramnios had a significantly higher rate of caesarean delivery for non-reassuring fetal heart rate patterns compared to women with normal amniotic fluid volume.[6] This suggests that even a mild reduction in amniotic fluid volume may compromise the fetal environment, particularly during labor.

The significantly higher rate of meconium-stained amniotic fluid observed in our borderline AFI group (36.7% versus 16.7%, p=0.013) is consistent with the results reported by Gumus et al, who also found a positive correlation between declining AFI and the presence of meconium-stained amniotic fluid.[7] Meconium passage in utero is often considered a sign of fetal hypoxic stress and is associated with increased risk of respiratory morbidity in the neonate. The observed association between borderline AFI and meconium staining in our study suggests that the reduced amniotic fluid volume may contribute to increased fetal stress during labor.

The significantly higher rate of NICU admissions in the borderline AFI group (23.3% versus 10.0%, p=0.048) and longer NICU stays (3.6±1.8 days versus 2.8±1.2 days, p=0.042) highlight the clinical relevance of borderline AFI as a risk factor for neonatal morbidity. Similar findings were reported by Jamal et al, who found that NICU admission rates were significantly higher in pregnancies with borderline AFI compared to those with normal AFI.[1] This increased need for intensive neonatal care suggests that borderline AFI may be associated with subtle but clinically significant fetal compromise that manifests as neonatal adaptation difficulties.

The lower umbilical cord pH values observed in the borderline AFI group (7.24±0.08 versus 7.28±0.07, p=0.004) provide objective evidence of increased fetal acidosis in these pregnancies. This finding is particularly important as it provides a physiological basis for the higher rates of fetal distress and subsequent interventions observed in the borderline AFI group. Magann et al have emphasized the importance of umbilical cord blood gas analysis as an objective measure of intrapartum fetal well-being, and our findings suggest that borderline AFI may be associated with subtle but measurable changes in the fetal acid-base status.[8]

Our subgroup analysis revealing worse outcomes in pregnancies with AFI 5-6.5 cm compared to those with AFI 6.6-8 cm suggests a dose-response relationship between decreasing amniotic fluid volume and increasing perinatal risk, even within the borderline range. This finding is novel and has important clinical implications, as it suggests that the lower end of the borderline AFI spectrum may warrant closer monitoring and possibly earlier intervention compared to the higher end. Choi proposed a similar concept, suggesting that the risk of adverse perinatal outcomes increases progressively as the AFI decreases below the normal range.[9-12]

The pathophysiological mechanisms underlying the association between borderline AFI and adverse perinatal outcomes remain incompletely understood. One possibility is that reduced amniotic fluid volume, even at borderline levels, may lead to increased cord compression during uterine contractions, resulting in variable decelerations and potential fetal hypoxia. This hypothesis is supported by our finding of higher rates of variable decelerations in the borderline AFI group (21.7% versus 10.0%). Mulvihill et al have described the protective role of adequate amniotic fluid in preventing umbilical cord compression and maintaining fetal well-being during labor.[2]

Another possible mechanism is that borderline AFI may represent an early manifestation of subtle placental dysfunction that has not yet resulted in overt oligohydramnios but is sufficient to compromise fetal reserve during the stress of labor. This hypothesis is supported by the lower birth weights and increased rates of fetal distress observed in our borderline AFI group.[13,14]

The clinical implications of our findings are significant. First, they suggest that borderline AFI should be considered a risk factor for adverse perinatal outcomes and may warrant increased antenatal surveillance. Second, the dose-response relationship observed within the borderline AFI range suggests that the management approach may need to be tailored based on the specific AFI value, with possibly more intensive monitoring for those at the lower end of the borderline spectrum.[15]

Our study has several strengths, including its prospective design, standardized protocol for AFI measurement, comprehensive assessment of both maternal and neonatal outcomes, and careful exclusion of confounding factors such as fetal anomalies, premature rupture of membranes, and maternal medical complications. However, certain limitations must be acknowledged. The relatively small sample size may have limited the statistical power to detect differences in some outcomes, particularly rare events such as perinatal mortality. Additionally, the study was conducted at a single center, which may limit the generalizability of the findings to other settings.

CONCLUSION

This prospective observational study demonstrated that borderline AFI (5-8 cm) at term is associated with significantly higher rates of adverse perinatal outcomes compared to normal AFI. We observed increased rates of fetal distress requiring caesarean delivery, meconium-stained amniotic fluid, NICU admissions, and lower umbilical cord pH values in the borderline AFI group. Furthermore, our subgroup analysis revealed a dose-response relationship between decreasing AFI within the borderline range and worsening outcomes. These findings suggest that borderline AFI represents a clinically significant condition that warrants increased surveillance and modified management to optimize perinatal outcomes.

Larger multicenter studies are needed to develop evidence-based guidelines for managing pregnancies with borderline AFI.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Sharma M, Gupta S, Kothari A. Effect of borderline amniotic fluid index in last trimester on perinatal outcome in eastern India: a prospective observational study. Int J Reprod Contracept Obstet Gynecol 2025;14:2963-8.