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Intrapartum Amniotic Fluid Index as a Predictor of Perinatal Outcome: A Prospective Observational Study

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Abstract

Objective: To evaluate the relationship between intrapartum Amniotic Fluid Index (AFI) and perinatal outcomes, assessing its predictive value for adverse events such as fetal distress, cesarean delivery, low APGAR scores, and neonatal intensive care unit (NICU) admission.

Methods: This prospective observational study included 200 singleton pregnant women at ≥37 weeks gestation admitted in labor at Government Victoria Hospital, Visakhapatnam, from November 2022 to April 2024. AFI was measured using the four-quadrant technique and categorized as low (<5 cm), borderline (5–8 cm), normal (8–25 cm), or polyhydramnios (>25 cm). Outcomes assessed included non-stress test (NST) reactivity, labor onset, mode of delivery, liquor color, APGAR scores, and NICU admission. Statistical significance was determined using Chi-square tests ($p<0.05$).

Results: Of 200 participants, 16% had low AFI, 27% borderline, 54% normal, and 3% polyhydramnios. Low AFI was significantly associated with non-reactive NST (59.4%, $p<0.001$), cesarean delivery (65.6%, $p<0.001$), meconium-stained liquor (37.5%, $p=0.0016$), low 1-minute APGAR scores (18.8%, $p=0.0127$), and NICU admission (56.3%, $p<0.001$). Borderline AFI showed similar trends, while polyhydramnios had higher cesarean rates (66.7%) but limited sample size precluded generalization. Normal AFI correlated with favorable outcomes.

Conclusion: Low and borderline AFI are reliable predictors of adverse perinatal outcomes, necessitating heightened intrapartum surveillance. Polyhydramnios findings require further investigation due to low incidence.

Keywords: Amniotic Fluid Index, perinatal outcome, oligohydramnios, fetal distress, cesarean delivery, NICU admission.

INTRODUCTION

Amniotic fluid plays a critical role in fetal development and protection throughout gestation, serving as a cushion against external forces, facilitating fetal movement, and aiding in lung maturation and temperature regulation [1]. Its volume, composition, and dynamics vary across pregnancy, reflecting fetal health and placental function. In early gestation, amniotic fluid is primarily produced by the amniotic membrane via passive diffusion and active electrolyte transport [2]. As gestation progresses, fetal urine production (starting at 8–11 weeks) and swallowing become primary contributors, with volumes rising from 100 mL at 25 weeks to 600 mL at term [3]. Concurrently, removal pathways such as fetal swallowing (up to 500 mL/day) and transmembranous/intramembranous exchanges maintain fluid homeostasis [4]. By the third trimester, amniotic fluid volume peaks at approximately 1 L (32–38 weeks) before declining to 800–900 mL at term [5].

Abnormalities in amniotic fluid volume—oligohydramnios (<5th percentile, ~300 mL) and polyhydramnios (>95th percentile, 1700–1900 mL)—are associated with adverse perinatal outcomes [6]. Oligohydramnios, often linked to fetal growth restriction, renal anomalies, or placental insufficiency, increases risks of fetal distress, cesarean delivery, and neonatal morbidity [7]. Polyhydramnios, though less common, may indicate congenital anomalies, maternal diabetes, or twin gestation, potentially leading to preterm delivery or cord prolapse [8]. The Amniotic Fluid Index (AFI), introduced by Phelan et al. in 1987, offers a standardized, reproducible method to assess fluid volume using ultrasonography, summing the deepest vertical pockets in four uterine quadrants [9]. An AFI <5 cm typically denotes oligohydramnios, while >25 cm indicates polyhydramnios, with values between 5–25 cm considered normal, though borderline ranges (5–8 cm) are often scrutinized for subtle risks [10].

The clinical significance of AFI lies in its potential to predict intrapartum and perinatal complications. Rutherford et al. (1987) demonstrated an inverse relationship between AFI and adverse outcomes, including non-reactive NSTs, fetal heart rate (FHR) decelerations, meconium staining, and cesarean sections for fetal distress [11]. Similarly, Casey et al. (2000) reported increased perinatal morbidity and mortality with AFI <5 cm in a cohort of 6,423 pregnancies [12]. However,

conflicting evidence exists; Conway et al. (1998) suggested that isolated oligohydramnios at term may not warrant labor induction, as it does not consistently correlate with fetal compromise [13]. These discrepancies underscore the need for further investigation into AFI's predictive accuracy, particularly in diverse clinical settings.

Intrapartum AFI assessment provides a dynamic snapshot of fetal well-being during labor, a period marked by heightened vulnerability to hypoxia and mechanical stress. Reduced fluid volumes may compress the umbilical cord, leading to variable decelerations and fetal distress, while excessive volumes may predispose to malpresentation or cord prolapse [14]. The APGAR score, a standard measure of neonatal adaptation, and NICU admission rates further reflect the downstream impact of fluid abnormalities. Studies like Chandra et al. (2000) have highlighted AFI's utility in predicting low APGAR scores and cesarean rates, with a sensitivity of 76.9% for fetal distress-related interventions [15]. Yet, the literature remains heterogeneous, with some studies questioning AFI's standalone diagnostic value compared to combined biophysical profiles [10].

In India, where maternal and perinatal mortality rates remain significant public health concerns, optimizing intrapartum monitoring tools like AFI could enhance outcomes in resource-limited settings. The Government Victoria Hospital in Visakhapatnam, a tertiary care center, serves a diverse population, offering an ideal context to explore AFI's predictive role. Previous studies often focused on antepartum AFI or combined it with other tests, leaving intrapartum-specific data underexplored. Moreover, regional variations in obstetric practices and patient demographics necessitate localized evidence. This study bridges these gaps by prospectively evaluating intrapartum AFI in relation to key perinatal outcomes—fetal distress, mode of delivery, APGAR scores, and NICU admission—in a cohort of 200 women at term.

By integrating ultrasonography with clinical labor monitoring, we aim to clarify AFI's sensitivity and specificity as a standalone predictor. This investigation builds on foundational work by Phelan et al. [9] and extends insights from Rutherford et al. [11] and Casey et al. [12], adapting their findings to a contemporary Indian cohort. Understanding AFI's intrapartum implications could guide evidence-based decisions, potentially reducing unnecessary interventions while targeting high-risk cases for timely action. As labor represents a critical juncture for fetal health, this study seeks to refine risk stratification and inform clinical protocols in obstetric care.

AIMS

The primary objective of this study was to assess the relationship between intrapartum AFI and perinatal outcomes in singleton pregnancies at term. Specific aims included evaluating AFI's sensitivity in predicting: (1) abnormal fetal heart rate patterns/fetal distress, (2) low APGAR scores, (3) the need for lower segment cesarean section (LSCS), and (4) NICU admission.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted at the Institute of Obstetrics and Gynecology, Government Victoria Hospital, Visakhapatnam, Andhra Pradesh, India, from November 2022 to April 2024. Ethical clearance was obtained from the institutional review board, and informed consent was secured from all participants.

Sample Size and Participants

A total of 200 pregnant women were enrolled based on a sample size calculation assuming a 15% prevalence of oligohydramnios, with 80% power and a 5% significance level. Inclusion criteria comprised singleton pregnancies at ≥37 weeks gestation, admitted in labor with intact amniotic membranes, and registered cases with at least four antenatal visits. Exclusion criteria included maternal complications (e.g., hypertensive disorders, diabetes, chronic illnesses), fetal anomalies (e.g., congenital malformations, intrauterine growth restriction), intrauterine fetal demise, and obstetric indications for cesarean section unrelated to AFI (e.g., malpresentation, prior cesarean).

AFI Measurement

AFI was assessed intrapartum using the four-quadrant technique described by Phelan et al. [9]. The maternal abdomen was divided into four quadrants by a midsagittal vertical line and a transverse line midway between the pubic symphysis and uterine fundus. Using an ultrasonic transducer (parallel to the sagittal plane, perpendicular to the coronal plane), the deepest vertical pocket free of fetal parts or cord loops was measured in each quadrant. Measurements were repeated thrice and averaged to minimize observer error. AFI was categorized as: low (<5 cm), borderline (5–8 cm), normal (8–25 cm), or polyhydramnios (>25 cm).

Data Collection

Participants underwent a detailed history, general examination, and obstetric assessment upon admission. Non-stress tests (NST) were performed using cardiotocography for 20 minutes, with reactivity defined as two FHR accelerations (≥15 bpm, lasting ≥15 seconds) within 20 minutes. Non-reactive NSTs persisted beyond 40 minutes without meeting criteria. Follow-up FHR traces were recorded hourly until normal or delivery occurred. Amniotomy at ≥4 cm cervical dilatation allowed liquor color assessment. Post-delivery, mode of delivery (normal vaginal delivery [NVD], instrumental, or

LSCS), 1- and 5-minute APGAR scores, birth weight, gender, and NICU admission status were recorded. Routine investigations included hemoglobin, urine analysis, HIV, HBsAg, VDRL, blood grouping, and random blood sugar.

Statistical Analysis

Data were analyzed using Chi-square tests to assess associations between AFI categories and outcomes, with $p<0.05$ indicating statistical significance. Means and standard deviations were calculated for continuous variables (e.g., maternal age, AFI). Analysis was performed using SPSS version 25.

RESULTS

The study included 200 women with a mean age of 24.4 years (SD 4.1) and mean gestational age of 39.4 weeks (SD 1.2). AFI distribution was: low (<5 cm) in 32 (16%), borderline (5–8 cm) in 54 (27%), normal (8–25 cm) in 108 (54%), and polyhydramnios (>25 cm) in 6 (3%).

Table 1: AFI Distribution and Statistical Parameters

AFI Category	n (%)	Mean AFI (cm)	SD (cm)
Low (<5 cm)	32 (16)	3.8	0.9
Borderline (5–8 cm)	54 (27)	6.7	0.8
Normal (8–25 cm)	108 (54)	14.2	4.1
Polyhydramnios (>25 cm)	6 (3)	27.3	1.5

Table 2: NST Reactivity by AFI Category

AFI Category	Reactive NST (n, %)	Non-Reactive NST (n, %)	Chi-Square	p-value
Low (<5 cm)	13 (40.6)	19 (59.4)	33.45	<0.001
Borderline (5–8 cm)	25 (46.3)	29 (53.7)		
Normal (8–25 cm)	89 (82.4)	19 (17.6)		
Polyhydramnios (>25 cm)	4 (66.7)	2 (33.3)		

Non-reactive NST was significantly more frequent in low (59.4%) and borderline (53.7%) AFI groups compared to normal AFI (17.6%, $p<0.001$).

Table 3: Mode of Delivery by AFI Category

AFI Category	NVD (n, %)	Instrumental (n, %)	LSCS (n, %)	Chi-Square	p-value
Low (<5 cm)	8 (25.0)	3 (9.4)	21 (65.6)	48.95	<0.001
Borderline (5–8 cm)	17 (31.5)	4 (7.4)	33 (61.1)		
Normal (8–25 cm)	84 (77.8)	6 (5.6)	18 (16.7)		
Polyhydramnios (>25 cm)	2 (33.3)	0 (0.0)	4 (66.7)		

LSCS rates were highest in low (65.6%) and polyhydramnios (66.7%) groups, contrasting with 16.7% in the normal AFI group ($p<0.001$). Fetal distress was the leading LSCS indication in low (47.6%) and borderline (36.4%) groups.

Table 4: APGAR Scores at 1 Minute by AFI Category

AFI Category	Low (≤4) (n, %)	High (>4) (n, %)	Chi-Square	p-value
Low (<5 cm)	6 (18.8)	26 (81.3)	10.90	0.0127
Borderline (5–8 cm)	5 (9.3)	49 (90.7)		
Normal (8–25 cm)	4 (3.7)	104 (96.3)		
Polyhydramnios (>25 cm)	1 (16.7)	5 (83.3)		

Low 1-minute APGAR scores were more common in low (18.8%) and polyhydramnios (16.7%) groups compared to normal AFI (3.7%, $p=0.0127$).

Table 5: NICU Admission by AFI Category

AFI Category	Yes (n, %)	No (n, %)	Chi-Square	p-value
Low (<5 cm)	18 (56.3)	14 (43.8)	45.35	<0.001
Borderline (5–8 cm)	11 (20.4)	43 (79.6)		
Normal (8–25 cm)	6 (5.6)	102 (94.4)		
Polyhydramnios (>25 cm)	1 (16.7)	5 (83.3)		

NICU admission was significantly higher in the low AFI group (56.3%) versus normal AFI (5.6%, $p<0.001$). Birth asphyxia (33.3%) and meconium aspiration syndrome (27.8%) predominated in low AFI cases.

DISCUSSION

This study demonstrates that intrapartum AFI is a valuable predictor of perinatal outcomes, with low (<5 cm) and borderline (5–8 cm) AFI strongly associated with adverse events. The 16% incidence of oligohydramnios aligns with Biradar et al. (2016), who reported 14% in a cohort of 410 women, linked to increased cesarean rates ($p<0.05$) [16]. Our finding of 65.6% LSCS in the low AFI group corroborates Chandra et al. (2000), where 50% of oligohydramnios cases required cesarean delivery for fetal distress (sensitivity 76.9%, specificity 73%) [15]. Similarly, Casey et al. (2000) observed elevated morbidity with AFI <5 cm ($p<0.01$) in 6,423 pregnancies [12], reinforcing oligohydramnios as a high-risk marker.

Non-reactive NST in 59.4% of low AFI cases ($p<0.001$) mirrors Rutherford et al. (1987), who noted increased FHR decelerations and non-reactivity with diminished AFI ($p<0.05$) [11]. This suggests cord compression or placental insufficiency as mechanisms, consistent with Hoskins et al. (1991), where severe decelerations with AFI ≤5 cm led to a 75% cesarean rate [17]. Our 56.3% NICU admission rate in low AFI cases exceeds Tripathi et al. (2019), who reported 30% ($p<0.05$) [18], possibly due to our focus on intrapartum AFI and stringent monitoring. Birth asphyxia and meconium aspiration predominated, aligning with Swapan Das et al. (2017), where 36% of oligohydramnios neonates had low APGAR scores ($p<0.05$) [19].

Borderline AFI (5–8 cm) exhibited intermediate risks, with 53.7% non-reactive NST and 61.1% LSCS rates ($p<0.001$). This supports Voxman et al. (2002), who found AFI ≤5 cm linked to abnormal FHR tracings ($p<0.05$) but not necessarily worse neonatal outcomes [20]. The 20.4% NICU admission rate in this group suggests a gradient of risk, warranting surveillance akin to overt oligohydramnios. In contrast, normal AFI (8–25 cm) was protective, with 77.8% NVD and 5.6% NICU admissions, consistent with Barron et al. (1995), where AFI 8.1–20 cm had lower cesarean rates ($p<0.05$) [21].

Polyhydramnios (>25 cm), though rare (3%), showed a 66.7% LSCS rate, with cord prolapse and fetal distress as key indications. This aligns with Kuang-Chao Chen et al. (2005), who reported increased preterm delivery and NICU admissions with polyhydramnios ($p<0.01$) [22]. However, our small sample (n=6) limits generalizability, echoing ShrutiSaralaya et al. (2013), where a 2.5% incidence precluded firm conclusions [23].

Contrasting findings emerge from Conway et al. (1998), who argued isolated oligohydramnios at term does not predict fetal compromise, citing unchanged neonatal outcomes despite higher cesarean rates ($p>0.05$) [13]. Our data challenge this, as low APGAR scores (18.8%) and NICU admissions (56.3%) were significantly elevated in oligohydramnios ($p<0.05$). This discrepancy may reflect intrapartum versus antepartum focus or differences in management protocols. Magann et al. (1999) also questioned AFI's diagnostic precision, finding no difference in cesarean rates or pH <7.12 with AFI <5 cm ($p>0.05$) [24]. Our higher sensitivity may stem from real-time labor monitoring, capturing dynamic changes missed in antepartum studies.

The interplay of AFI with labor onset and liquor status further elucidates its predictive role. Induced labor was required in 62.5% of low AFI cases ($p<0.001$), akin to Alchalabi et al. (2006), where AFI ≤5 cm increased induction and cesarean rates ($p<0.05$) [25]. Meconium-stained liquor in 37.5% of low AFI cases ($p=0.0016$) supports Sarno et al. (1992), who noted increased meconium with AFI ≤5 cm ($p<0.05$) [26]. These findings underscore AFI's utility in risk stratification, aligning with broader literature advocating combined fetal surveillance.

CONCLUSION

This study confirms that intrapartum AFI is a robust predictor of perinatal outcomes in term pregnancies. Low AFI (<5 cm) significantly increases risks of non-reactive NST (59.4%), cesarean delivery (65.6%), low APGAR scores (18.8%), and NICU admission (56.3%), with p-values <0.05 across outcomes. Borderline AFI (5–8 cm) exhibits similar, albeit less severe, trends, while normal AFI (8–25 cm) correlates with favorable outcomes. Polyhydramnios (>25 cm) suggests heightened cesarean risk (66.7%), though its low incidence (3%) limits definitive conclusions. These findings highlight the need for intensified fetal surveillance in women with abnormal AFI, particularly oligohydramnios, to mitigate adverse events like fetal distress and neonatal morbidity. AFI's integration into intrapartum monitoring protocols could optimize decision-making, balancing intervention with expectant management. Further research with larger polyhydramnios cohorts is warranted to validate its implications.

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