



## Association of Amniotic Fluid Index with Fetomaternal Outcomes

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### Declaration

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All authors equally contributed to the study and approved the final manuscript

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### ABSTRACT

**Background:** Amniotic fluid index is an established marker of fetal renal function, placental activity, and overall intrauterine well-being. Abnormal levels, particularly oligohydramnios, are associated with adverse pregnancy outcomes, including cesarean delivery and increased neonatal morbidity. **Objective:** To determine the association of low amniotic fluid index with adverse fetomaternal outcomes. **Study Design:** Cohort study. **Duration and Place of Study:** This study was conducted over six months, from December 2024 to May 2025, in the Department of Obstetrics and Gynecology, District Headquarters Teaching Hospital, Dera Ismail Khan. **Methodology:** A total of 228 women aged 18–40 years, carrying singleton pregnancies beyond 20 weeks, were included. Participants were categorized into two groups: exposed (AFI  $\leq$ 5.0 cm) and unexposed (AFI 5.1–25 cm). Pregnancies with comorbidities or high-risk factors were excluded. Maternal outcome was assessed in terms of cesarean delivery, while neonatal outcome was evaluated by the requirement of NICU admission. **Results:** Cesarean delivery occurred in 46.5% of the exposed group compared to 6.1% of the unexposed group ( $p < 0.001$ , RR=7.62, 95% CI: 3.65–15.92). NICU admission was required in 27.2% of neonates in the exposed group versus 8.8% in the unexposed group ( $p < 0.001$ , RR=3.10, 95% CI: 1.61–5.97). **Conclusion:** Low AFI is significantly associated with increased cesarean delivery and NICU admission.

### INTRODUCTION

Amniotic fluid index (AFI) is a useful parameter of the intrauterine environment and overall fetal well-being.<sup>1</sup> It is calculated by summing the vertical diameters of the deepest fluid pockets in the four quadrants of the uterus and is a placental activity and fetal renal function marker.<sup>2</sup> In the normal range, AFI indicates good uteroplacental circulation and production of fetal urine.<sup>3</sup> Abnormal values such as oligohydramnios, however, point towards the presence of pathology and unfavorable pregnancy outcomes.<sup>4</sup> For this reason, assessment of AFI is considered a key component of antenatal monitoring, particularly in high-risk pregnancies.

Low amniotic fluid index is also consistently observed in association with high risk of cesarean birth.<sup>5</sup> Oligohydramnios also tends to induce a non-reassuring fetal heart pattern, meconium-staining of liquor and poor labor tolerance and also necessitates operative intervention for the prevention of intrapartum complications.<sup>6</sup> Besides this the reduced cushioning effect of amniotic fluid also predisposes for umbilical cord compression and results in a high incidence of emergency cesarean deliveries.<sup>7</sup> Therefore the diagnosis at early gestation of low amniotic fluid index assists obstetricians

in predicting such risks and making mode of delivery in an evidenced-based manner.

Neonates whose mothers have low amniotic fluid index have an enhanced risk of admission in neonatal intensive care units.<sup>8</sup> The suboptimal intrauterine environment potentially leads to intrauterine growth retardation, respiratory distress and birth asphyxia for which they need special care after birth.<sup>9</sup> The association also with perinatal hypoxia and meconium aspiration syndrome suggests the vulnerability of such neonates.<sup>9</sup> Maternal outcomes also are indirectly affected secondary to the application of operative interventions and associated morbidity.<sup>10</sup> Most of the studies strongly indicate a need for routine amniotic fluid index estimation as a predictor for the better fetomaternal outcomes.

In a retrospective observational cohort study conducted by Kansara VM et al., 100 term pregnancies with sonographic evidence of isolated oligohydramnios (amniotic fluid index  $<$ 5 cm) were evaluated. Pregnancies complicated by uterine anomalies or other high-risk conditions were excluded. The study compared mode of delivery and perinatal outcomes with a control group of pregnancies having normal amniotic fluid levels (AFI 5–25 cm). Findings demonstrated that the rate of lower segment

cesarean section was 40% in the oligohydramnios group compared to 8% in the control group, while neonatal intensive care unit admission was required in 24% of cases versus 10% in those with normal amniotic fluid.<sup>11</sup>

Extremely few regional analyses from Dera Ismail Khan are available regarding the clinical impact of reduced amniotic fluid index on the fetomaternal wellbeing and the neonate. Available data are mainly collected from abroad or major cities and may not reflect the regional demographic profile, nutritional profile, and profile of care. Determination of the association of low amniotic fluid index with adverse fetomaternal outcomes in this series is therefore of relevance in terms of guiding interventions in a timely way so as to reduce preventable complications and strengthen obstetric care practices in the regional care setting.

## METHODOLOGY

This cohort study was carried out in the Department of Obstetrics and Gynecology at District Headquarters Teaching Hospital, Dera Ismail Khan, over a six-month period from December 2024 to May 2025. Approval for the study was obtained from the institutional review board prior to patient recruitment. All procedures were conducted in accordance with ethical standards, and the confidentiality of participants was maintained throughout the research process.

The required sample size was estimated using the OpenEpi sample size calculator, with a confidence level of 95% and a power of 80%. The expected frequency of neonatal intensive care admission was taken as 24% in pregnancies with low amniotic fluid index and 10% in those with normal amniotic fluid levels.<sup>11</sup> Based on these parameters, a total of 228 women were included, equally divided into an exposed group with reduced amniotic fluid index and an unexposed group with normal levels. Participants were enrolled through non-probability consecutive sampling.

Women aged 18 to 40 years, carrying a singleton pregnancy beyond 20 weeks of gestation, and of any parity were eligible. The exposed group comprised women with an amniotic fluid index of 5.0 cm or less on ultrasonography, while the unexposed group consisted of those with values between 5.1 and 25 cm. Patients with uterine anomalies, hypertensive disorders of pregnancy, preeclampsia, diabetes, chronic renal or cardiac disease, previous cesarean scars, or any condition defining a high-risk pregnancy were not considered.

Written informed consent was obtained from all participants after explaining the study objectives, the voluntary nature of participation, and assurance of no harm. Each participant underwent a detailed history and physical examination at the time of recruitment. Pregnancies were then followed until delivery to observe maternal and neonatal outcomes. Low amniotic fluid index was defined as  $\leq 5.0$  cm measured on ultrasound, whereas normal index was considered 5.1–25 cm. Adverse outcomes of interest included the need for cesarean

delivery and admission of the newborn to neonatal intensive care. Cesarean birth was identified when delivery occurred through a lower abdominal incision, and neonatal intensive care admission was recorded when an infant required specialized care due to distress, diagnosed by abnormal fetal heart rate patterns ( $>160$  bpm or  $<120$  bpm) on auscultation or continuous electronic fetal monitoring.

Data were analyzed using IBM SPSS version 25. Continuous variables were expressed as mean with standard deviation or median with interquartile range where appropriate. Categorical variables were presented as frequencies and percentages. Comparisons between the exposed and unexposed groups were performed using the chi-square test, with a p-value of  $\leq 0.05$  considered statistically significant. Relative risk was calculated to quantify the strength of association. Stratified analyses were performed for potential effect modifiers, with post-stratification chi-square testing applied to assess statistical significance.

## RESULTS

Patient demographics revealed similar baseline characteristics between groups, with mean age of  $28.58 \pm 7.07$  years in the exposed group versus  $29.65 \pm 6.37$  years in the unexposed group, parity of  $1.77 \pm 1.63$  versus  $1.89 \pm 1.60$ , gestational age of  $31.08 \pm 5.61$  weeks versus  $30.04 \pm 5.68$  weeks, and BMI of  $23.96 \pm 3.24$  kg/m<sup>2</sup> versus  $24.58 \pm 2.96$  kg/m<sup>2</sup> respectively. Residential status differed between groups, with 74 (64.9%) rural and 40 (35.1%) urban participants in the exposed group compared to 49 (43.0%) rural and 65 (57.0%) urban in the unexposed group. Socioeconomic distribution showed 54 (47.4%) poor, 39 (34.2%) middle, and 21 (18.4%) rich participants in the exposed group versus 30 (26.3%) poor, 57 (50.0%) middle, and 27 (23.7%) rich in the unexposed group (as shown in Table-I).

**Table I**  
*Patient Demographics*

Demographics	Exposed Group (n=114)	Unexposed Group (n=114)
Age (years)	28.58±7.07	29.65±6.37
Parity	1.77±1.63	1.89±1.60
Gestational Age (weeks)	31.08±5.61	30.04±5.68
BMI (kg/m <sup>2</sup> )	23.96±3.24	24.58±2.96
<b>Residential Status</b>		
Rural n (%)	74 (64.9%)	49 (43.0%)
Urban n (%)	40 (35.1%)	65 (57.0%)
<b>Socioeconomic Status</b>		
Poor n (%)	54 (47.4%)	30 (26.3%)
Middle n (%)	39 (34.2%)	57 (50.0%)
Rich n (%)	21 (18.4%)	27 (23.7%)

The primary outcomes demonstrated significantly higher rates of cesarean section in the exposed group with 53 (46.5%) cases compared to 7 (6.1%) in the unexposed group ( $p < 0.001$ , RR=7.62, 95% CI: 3.65-15.92). NICU admissions were also significantly more frequent in the exposed group with 31 (27.2%) cases versus 10 (8.8%) in the unexposed group ( $p < 0.001$ , RR=3.10, 95% CI: 1.61-5.97) (as shown in Table-II).

**Table II**  
Comparison of fetomaternal outcomes between the two groups (n=128)

Outcomes	Exposed Group n=114 n (%)	Unexposed Group n=114 n (%)	P value	Relative Risk (95% CI)
<b>C-Section</b>				
Yes	53 (46.5%)	7 (6.1%)	<0.001	7.62 (3.65-15.92)
No	61 (53.5%)	107 (93.9%)		
Total	114 (100%)	114 (100%)		
<b>NICU Admission</b>				
Yes	31 (27.2%)	10 (8.8%)	<0.001	3.10 (1.61-5.97)
No	83 (72.8%)	104 (91.2%)		
Total	114 (100%)	114 (100%)		

Stratified analysis of cesarean section rates by demographic variables revealed significant associations across multiple subgroups. Among participants aged  $\leq 30$  years, the exposed group had 29 (43.9%) cesarean sections compared to 5 (8.2%) in the unexposed group ( $p=0.535$ , RR=1.14, 95% CI: 0.78-1.66), while in those  $>30$  years, rates were 24 (50.0%) versus 2 (3.8%) respectively ( $p<0.001$ , RR=13.16, 95% CI: 3.30-52.52). For parity  $\leq 3$ , cesarean rates were 40 (44.0%) in exposed versus 7 (7.6%) in unexposed groups ( $p<0.001$ , RR=5.79, 95% CI: 2.82-11.89), and for parity  $>3$ , rates were 13 (56.5%) versus 0 (0.0%) respectively ( $p<0.001$ ). Rural participants showed cesarean rates of 33 (44.6%) in exposed versus 6 (12.2%) in unexposed groups ( $p<0.001$ , RR=3.66, 95% CI: 1.63-8.22), while urban participants had rates of 20

(50.0%) versus 1 (1.5%) respectively ( $p<0.001$ , RR=33.33, 95% CI: 4.74-234.49). Across socioeconomic strata, poor participants had cesarean rates of 24 (44.4%) versus 5 (16.7%) ( $p=0.014$ , RR=2.67, 95% CI: 1.12-6.35), middle-class participants had rates of 16 (41.0%) versus 1 (1.8%) ( $p<0.001$ , RR=23.11, 95% CI: 3.20-166.95), and wealthy participants had rates of 13 (61.9%) versus 1 (3.7%) ( $p<0.001$ , RR=16.74, 95% CI: 2.36-118.67). BMI stratification showed that participants with BMI  $\leq 25$  kg/m<sup>2</sup> had cesarean rates of 36 (50.0%) versus 4 (6.3%) ( $p<0.001$ , RR=7.94, 95% CI: 3.02-20.87), while those with BMI  $>25$  kg/m<sup>2</sup> had rates of 17 (40.5%) versus 3 (6.0%) respectively ( $p<0.001$ , RR=6.75, 95% CI: 2.16-21.11) (as shown in Table-III).

**Table III**  
Association of C-Section with Demographic Variables

Demographics variables	Group	C-Section		P-value	Relative Risk (95% CI)
		Yes (n, %)	No (n, %)		
<b>Age (years)</b>					
$\leq 30$	Exposed	29 (43.9%)	37 (56.1%)	0.535	1.14 (0.78-1.66)
	Unexposed	5 (8.2%)	56 (91.8%)		
$>30$	Exposed	24 (50.0%)	24 (50.0%)	<0.001	13.16 (3.30-52.52)
	Unexposed	2 (3.8%)	51 (96.2%)		
<b>Parity</b>					
$\leq 3$	Exposed	40 (44.0%)	51 (56.0%)	<0.001	5.79 (2.82-11.89)
	Unexposed	7 (7.6%)	85 (92.4%)		
$>3$	Exposed	13 (56.5%)	10 (43.5%)	<0.001	-
	Unexposed	0 (0.0%)	22 (100.0%)		
<b>Residential Status</b>					
Rural	Exposed	33 (44.6%)	41 (55.4%)	<0.001	3.66 (1.63-8.22)
	Unexposed	6 (12.2%)	43 (87.8%)		
Urban	Exposed	20 (50.0%)	20 (50.0%)	<0.001	33.33 (4.74-234.49)
	Unexposed	1 (1.5%)	64 (98.5%)		
<b>Socioeconomic Status</b>					
Poor	Exposed	24 (44.4%)	30 (55.6%)	0.014	2.67 (1.12-6.35)
	Unexposed	5 (16.7%)	25 (83.3%)		
Middle	Exposed	16 (41.0%)	23 (59.0%)	<0.001	23.11 (3.20-166.95)
	Unexposed	1 (1.8%)	56 (98.2%)		
Rich	Exposed	13 (61.9%)	8 (38.1%)	<0.001	16.74 (2.36-118.67)
	Unexposed	1 (3.7%)	26 (96.3%)		
<b>BMI (kg/m<sup>2</sup>)</b>					
$\leq 25$	Exposed	36 (50.0%)	36 (50.0%)	<0.001	7.94 (3.02-20.87)
	Unexposed	4 (6.3%)	60 (93.8%)		
$>25$	Exposed	17 (40.5%)	25 (59.5%)	<0.001	6.75 (2.16-21.11)
	Unexposed	3 (6.0%)	47 (94.0%)		

NICU admission rates stratified by demographics showed consistent patterns of increased risk in the exposed group. Among participants aged  $\leq 30$  years, NICU admission rates were 17 (25.8%) in exposed versus 4 (6.6%) in unexposed groups ( $p=0.003$ , RR=3.91, 95% CI: 1.42-10.76), while in those  $>30$  years, rates were 14 (29.2%) versus 6 (11.3%) respectively ( $p=0.031$ , RR=2.58, 95% CI: 1.12-5.96). For parity  $\leq 3$ , NICU admission rates were 23 (25.3%) versus 9

(9.8%) ( $p=0.008$ , RR=2.58, 95% CI: 1.29-5.16), and for parity  $>3$ , rates were 8 (34.8%) versus 1 (4.5%) respectively ( $p=0.007$ , RR=7.73, 95% CI: 1.05-56.69). Rural participants had NICU admission rates of 19 (25.7%) versus 3 (6.1%) ( $p=0.004$ , RR=4.21, 95% CI: 1.31-13.49), while urban participants had rates of 12 (30.0%) versus 7 (10.8%) respectively ( $p=0.016$ , RR=2.78, 95% CI: 1.30-5.95). Socioeconomic stratification revealed that poor

participants had NICU admission rates of 14 (25.9%) versus 3 (10.0%) ( $p=0.076$ ,  $RR=2.59$ , 95% CI: 0.82-8.21), middle-class participants had rates of 12 (30.8%) versus 3 (5.3%) ( $p<0.001$ ,  $RR=5.85$ , 95% CI: 1.83-18.68), and wealthy participants had rates of 5 (23.8%) versus 4 (14.8%) ( $p=0.411$ ,  $RR=1.61$ , 95% CI: 0.52-4.97). BMI

stratification showed that participants with BMI  $\leq 25$  kg/m<sup>2</sup> had NICU admission rates of 19 (26.4%) versus 5 (7.8%) ( $p=0.003$ ,  $RR=3.38$ , 95% CI: 1.34-8.52), while those with BMI  $>25$  kg/m<sup>2</sup> had rates of 12 (28.6%) versus 5 (10.0%) respectively ( $p=0.013$ ,  $RR=2.86$ , 95% CI: 1.15-7.10) (as shown in Table-IV).

**Table IV**

Association of NICU Admission with Demographic Variables

Demographics variables	Group	NICU Admission		P-value	Relative Risk (95% CI)
		Yes (n, %)	No (n, %)		
<b>Age (years)</b>					
$\leq 30$	Exposed	17 (25.8%)	49 (74.2%)	0.003	3.91 (1.42-10.76)
	Unexposed	4 (6.6%)	57 (93.4%)		
$>30$	Exposed	14 (29.2%)	34 (70.8%)	0.031	2.58 (1.12-5.96)
	Unexposed	6 (11.3%)	47 (88.7%)		
<b>Parity</b>					
$\leq 3$	Exposed	23 (25.3%)	68 (74.7%)	0.008	2.58 (1.29-5.16)
	Unexposed	9 (9.8%)	83 (90.2%)		
$>3$	Exposed	8 (34.8%)	15 (65.2%)	0.007	7.73 (1.05-56.69)
	Unexposed	1 (4.5%)	21 (95.5%)		
<b>Residential Status</b>					
Rural	Exposed	19 (25.7%)	55 (74.3%)	0.004	4.21 (1.31-13.49)
	Unexposed	3 (6.1%)	46 (93.9%)		
Urban	Exposed	12 (30.0%)	28 (70.0%)	0.016	2.78 (1.30-5.95)
	Unexposed	7 (10.8%)	58 (89.2%)		
<b>Socioeconomic Status</b>					
Poor	Exposed	14 (25.9%)	40 (74.1%)	0.076	2.59 (0.82-8.21)
	Unexposed	3 (10.0%)	27 (90.0%)		
Middle	Exposed	12 (30.8%)	27 (69.2%)	$<0.001$	5.85 (1.83-18.68)
	Unexposed	3 (5.3%)	54 (94.7%)		
Rich	Exposed	5 (23.8%)	16 (76.2%)	0.411	1.61 (0.52-4.97)
	Unexposed	4 (14.8%)	23 (85.2%)		
<b>BMI (kg/m<sup>2</sup>)</b>					
$\leq 25$	Exposed	19 (26.4%)	53 (73.6%)	0.003	3.38 (1.34-8.52)
	Unexposed	5 (7.8%)	59 (92.2%)		
$>25$	Exposed	12 (28.6%)	30 (71.4%)	0.013	2.86 (1.15-7.10)
	Unexposed	5 (10.0%)	45 (90.0%)		

## DISCUSSION

The present study finds a significant association of amniotic fluid index abnormalities with adverse fetomaternal outcomes and exposed subjects having numerous folds more cesarean deliveries and admissions in the neonatal intensive care unit than controls. The seven-fold risk increase of cesarean section in the exposed subjects ought to be due to several pathophysiologic mechanisms of decreased amniotic fluid volumes. Oligohydramnios or decrease in amniotic fluid results in umbilical cord compression during contractions of the uterus and hence induces fetal hypoxia and requires urgent operative delivery in an endeavor to preclude perinatal morbidity. Polyhydramnios increases the risk for malpresentation and cord prolapse and uterine distension and affects effective contractions of the uterus and increases the risk for cesarean deliveries. The three-fold risk increase for NICU admissions in the exposed subjects reflects the direct effect of amniotic fluid abnormalities in the growth and maturation of the fetus. Oligohydramnios restricts the movements in the fetus and may induce intrauterine growth retardation and pulmonary hypoplasia due to reduction in the movements in the fetus and deformational abnormalities and polyhydramnios is a cause for preterm birth and rights distress and increases the risk for congenital malformations. The similar risk pattern for adverse outcomes across different demographic subgroups procure by the amniotic fluid index abnormalities point towards it as a common risk

factor existing across individual patient characteristics and underscore the primordial role of the amniotic fluid volume in the maintenance of the optimum intrauterine environment for the maturation of the fetus and successful parturition.

Our findings align closely with existing literature demonstrating strong associations between abnormal amniotic fluid index and adverse fetomaternal outcomes. The cesarean section rate of 46.5% in our exposed group is consistent with studies by Manisha et al.<sup>12</sup> (61.9%), Chattaraj et al.<sup>13</sup> (61.9%), Sharif et al.<sup>14</sup> (66.67%), Rehman et al.<sup>15</sup> (65%), and Vidyasagara et al.<sup>16</sup> (70.3%), all reporting significantly elevated operative delivery rates in oligohydramnios cases. However, our cesarean rate was notably lower than these studies, which may be attributed to differences in study populations, gestational age inclusion criteria, or management protocols. The significantly higher cesarean rates observed across all studies can be explained by the pathophysiological consequences of oligohydramnios, including increased risk of umbilical cord compression during labor, fetal distress, and the need for expedited delivery to prevent perinatal complications.

The NICU admission rate of 27.2% in our exposed group was lower compared to several studies including Manisha et al.<sup>12</sup> (71.4%), Chattaraj et al.<sup>13</sup> (71.4%), Hameed et al.<sup>17</sup> (42.9%), and Vidyasagara et al.<sup>16</sup> (35.9%), while being higher than Sharif et al.<sup>14</sup> (18.89%) and Lajber et al.<sup>18</sup> (12.5%). These variations in NICU admission rates

likely reflect differences in neonatal care protocols, institutional thresholds for admission, and severity of oligohydramnios in study populations. Interestingly, Lajber et al.<sup>18</sup> found no significant difference in cesarean section rates between oligohydramnios and control groups (29.17% vs 22.92%,  $p>0.05$ ), which contrasts sharply with our findings and most other studies. This discrepancy may be due to their smaller sample size ( $n=96$  vs  $n=228$  in our study) or different management approaches at their institution.

Our stratified analysis revealing higher risks across different demographic subgroups is supported by Rehman et al.<sup>15</sup> who found significantly higher cesarean rates in women  $>30$  years (60.3% vs 39.7%,  $p=0.0001$ ), consistent with our finding of increased operative delivery rates in older patients. The demographic variations in outcomes observed in our study reflect the multifactorial nature of pregnancy complications, where baseline maternal characteristics interact with amniotic fluid abnormalities to influence clinical outcomes. Studies by Hameed et al.<sup>17</sup> and Vidyasagara et al.<sup>16</sup> also demonstrated significant associations between low AFI and various adverse outcomes including low birth weight, meconium staining, and neonatal mortality, supporting our findings of increased morbidity in the exposed group. The consistent pattern of adverse outcomes across diverse populations and healthcare settings strengthens the evidence that abnormal amniotic fluid index serves as a reliable predictor of fetomaternal complications, regardless of geographic location or specific patient demographics.

Several limitations should be acknowledged in interpreting these findings. The single-center design may limit the generalizability of our results to other healthcare settings with different patient populations, management protocols, or resource availability. The relatively modest sample size of 228 participants, while adequate for

detecting significant differences in primary outcomes, may have limited statistical power for detecting smaller effect sizes in subgroup analyses, particularly in demographic stratifications with smaller cell sizes. The study design did not account for potential confounding variables such as maternal comorbidities, previous obstetric history, or specific indications for amniotic fluid index assessment, which could influence both exposure classification and outcomes. Additionally, the lack of standardized protocols for clinical decision-making regarding timing of delivery and NICU admission criteria may have introduced institutional bias in outcome assessment. The study also did not differentiate between degrees of oligohydramnios or polyhydramnios severity, which could provide more nuanced insights into the dose-response relationship between amniotic fluid volume and adverse outcomes.

## CONCLUSION

Our study has concluded that abnormal amniotic fluid index is significantly associated with adverse fetomaternal outcomes, demonstrating substantially increased risks of cesarean section and neonatal intensive care unit admissions in the exposed group compared to controls. The consistent pattern of elevated morbidity observed across various demographic subgroups reinforces the clinical importance of amniotic fluid volume assessment as a predictor of pregnancy complications.

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