ORIGINAL ARTICLE

Effect of Maternal Diabetes on Amniotic Fluid Index during the Second and Third Trimesters of Pregnancy: A Sonographic Case-Control Study

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Received: 04 April 2024 / Accepted: 30 December 2024

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Abstract

Purpose: Patients with diabetes are more likely to develop polyhydramnios. The rate of polyhydramnios among diabetic patients is increasing compared to non-diabetic patients.

To compare the Amniotic Fluid Index (AFI) of diabetic and non-diabetic patients using sonography.

Materials and Methods: A case-control study was conducted with 200 participants, comprising 100 diabetic patients and 100 non-diabetic patients. The study utilized a Toshiba XARIO XG ultrasound machine with a convex probe of 3.5-7.5 MHz frequency at the university ultrasound clinic in Green Town. All diabetic and gestational diabetic patients aged 18-45 years in their 2nd and 3rd trimesters were included. Patients with underlying pathologies such as hypertension or multiple gestations were excluded. Data analysis was performed using SPSS version 25.0.

Results: The mean amniotic fluid index in diabetic and non-diabetic groups was 21.19 and 13.20, respectively. The difference in the AFI between diabetics and non-diabetics was statistically significant (p=0.000). Chi-square analysis revealed a significant association between the AFI category and diabetes status. The diabetic group exhibited a higher proportion of cases in the polyhydramnios AFI category and a lower proportion in the normal AFI category compared to the non-diabetic group. The mean estimated fetal weight for diabetics and non-diabetics was 1341.64 and 1372.53 grams, respectively. There was no significant difference in estimated fetal weight between diabetic and non-diabetic patients (p=0.088).

Conclusion: The study concluded that diabetes during pregnancy is significantly associated with increased amniotic fluid levels, leading to a higher likelihood of polyhydramnios.

Keywords: Amniotic Fluid Index; Diabetes; Polyhydramnios; Ultrasonography; Oligohydramnios.

DOI:

1. Introduction

Ultrasound is a vital, non-invasive tool in prenatal care, offering detailed images of the fetus to monitor development and well-being. It plays a key role in confirming pregnancy, estimating gestational age, assessing fetal anatomy, tracking growth, and evaluating placental position. Additionally, ultrasound guides diagnostic procedures and determines fetal presentation, aiding in delivery planning. Its benefits include the early detection of complications, enabling timely interventions, enhancing prenatal care, and fostering a stronger bond between parents and the fetus. Overall, ultrasound significantly enhances pregnancy outcomes by providing comprehensive insights into fetal health and development [1].

Amniotic Fluid (AF) is a complex substance essential for fetal well-being [2] The Amniotic Fluid Index (AFI) is calculated as the summation of the largest vertical pockets in four quadrants, whereas the single deepest pocket technique measures the depth of the largest pocket of amniotic fluid [3]. Amniotic fluid (AF) was once considered a static pool, with a turnover rate of approximately one day [4] Amniotic Fluid (AF), commonly referred to as a pregnant woman's "water," is the protective fluid contained within the amniotic sac during pregnancy. AF safeguards the developing fetus by cushioning it against impacts to the mother's abdomen, facilitating easier fetal movement, and promoting musculoskeletal development. When swallowed by the fetus, AF aids in the maturation of the gastrointestinal tract. It also protects the fetus from mechanical shocks and jerks. Initially composed primarily of water and electrolytes, by approximately 12–14 weeks of gestation, the fluid also includes proteins, carbohydrates, lipids, phospholipids, and urea, all of which support fetal development [5] The amniotic fluid index (AFI) is typically measured at around 25 weeks of pregnancy. A normal AFI ranges between 8 cm and 18 cm. Oligohydramnios is diagnosed when the AFI is less than or equal to 8 cm, while polyhydramnios is diagnosed when it exceeds 18 cm. Additionally, the AFI is considered normal if the Maximum Vertical Pocket (MVP) measures between 2 cm and less than 8 cm [6].

Pregnancies at risk for adverse outcomes are managed through sonographic evaluation of AF. Antenatal assessment of AF is crucial, as it reflects long-term uteroplacental function. Deviations from normal AF volumes have been linked to adverse pregnancy outcomes [7]. In normal pregnancies, the mean AFI remained within the normal range, whereas in diabetic pregnancies, the values remained stable throughout the gestational ages studied [8] In a population at high risk for Gestational Diabetes Mellitus (GDM), the prevalence of GDM ranges from 30% to 40%. One of the common adverse effects of GDM is Fetal Macrosomia (FM) [9] The earliest and most sensitive indicator of gestational diabetes mellitus (GDM) is an increase in the amniotic fluid index (AFI). The AFI can predict GDM early, even before glucose concentrations are elevated [10].

Maternal diabetes, whether pre-existing or gestational, is associated with various complications that can impact both the mother and fetus. Among these complications, abnormal amniotic fluid levels either too high (polyhydramnios) or too low (oligohydramnios) are commonly observed and can lead to adverse pregnancy outcomes such as preterm delivery, fetal distress, or even perinatal mortality. The Amniotic Fluid Index (AFI), measured through ultrasound, is a critical parameter in monitoring fetal well-being and assessing amniotic fluid volume. However, the specific influence of maternal diabetes on AFI during the second and third trimesters remains inadequately explored, with existing research offering conflicting or incomplete findings. By establishing a clearer understanding of how maternal diabetes affects AFI, this research may contribute to better prediction and early intervention strategies for at-risk pregnancies.

2. Materials and Methods

The research was conducted at the University Ultrasound Clinic in Green Town, Lahore, using a Toshiba Xario XG with a 3.5 - 7.5 MHz convex probe. A convenience sampling technique was employed, and the study lasted for 7 months. A total of 200 patients participated, with 100 diabetic and 100 non-diabetic patients. Participants were included if they met the inclusion criteria and visited the clinic during the data collection period. All patients aged 18-45 years with diabetes or gestational diabetes during the 2nd and 3rd trimesters were included. Patients with underlying gestational pathologies such as gestational hypertension and multiple gestations were excluded. The AFI technique involves dividing the uterus into four equal quadrants. The transducer was kept perpendicular to the floor while the deepest pocket of amniotic fluid in each quadrant was located. A vertical measurement of each pocket was taken, avoiding areas containing extremities or the umbilical cord. The sum of these measurements, in centimeters, was used to calculate the AFI.

2.1. Data Analysis Procedure

Data were analyzed using SPSS software version 25.0. The mean ± standard deviation was calculated for quantitative variables. The AFI and estimated fetal weight of diabetic and non-diabetic subjects were compared using an independent t-test. The chi-square test was used to compare AFI appearance and AFI categories between diabetics and non-diabetics. A significance level of less than 0.05 was considered statistically significant.

3. Results

The mean age of the participants was 28.6 ± 4.9 years. Estimated fetal weight averages at 1310 ± 829.6 grams. The mean gestational age was 27.4 ± 5.11 weeks. By assessing amniotic fluid dynamics, the maximum vertical pocket measurement is 5.7 cm, signifying the maximum depth of amniotic fluid. The AFI holds clinical significance, averaging at 17.2 ± 5.0 cm. A majority of pregnancies exhibit a normal AFI category (52%), while a small percentage experiences polyhydramnios (0.5%) and oligohydramnios (47.5%). The appearance of AFI echoes provides additional information. The majority of cases (85%) show an echo-free appearance, while a minority exhibits low-level internal echoes (14%) or debris (1%) (Table 1).

Diabetic individuals (30.9 ± 4.5) tend to be older compared to non-diabetic individuals (26.2 ± 4.1), with a statistically significant P-value of 0.000. Diabetic individuals exhibit a higher AFI (21.1 ± 3.9) compared to non-diabetic individuals (13.2 ± 2.1), indicating increased amniotic fluid levels (Figure 1). The difference is statistically significant (P-value: 0.000). The maximum vertical pocket measurement is higher in diabetic individuals (7.61 ± 7.09) compared to non-diabetic individuals (3.9 ± 1.1), and the difference is statistically significant (P-value: 0.000). Diabetic individuals have a higher estimated fetal weight (1451.7 ± 770.6) compared to non-diabetic individuals (1168.6 ± 865.5), and the difference is statistically significant (P-value: 0.015). The distribution of AFI categories differs significantly between diabetic and non-diabetic individuals. Diabetic individuals show a higher prevalence of polyhydramnios (0.5%) and oligohydramnios (47.5%) compared to non-diabetic individuals (0% and 0%, respectively), with a significant P-value of 0.000. The appearance of AFI, categorized as echo-free, low-level internal echoes, and debris, shows no statistically significant differences between diabetic and non-diabetic individuals (Table 2). Estimated fetal weight showed a significant correlation with gestational age and amniotic fluid index (Figures 2 and 3).

Table 1. Descriptive Statistics of age, EFW, gestational age, MVP, AFI, status of diabetes, category, and appearance of AFI

Variables	Frequency and Percentages
Age (years)	28.6 ± 4.9
Estimated Fetal Weight (grams)	1310 ± 829.6
Gestational Age (weeks + days)	27.4 ± 5.11
Maximum Vertical Pocket (cm)	5.7 ± 5.8
Amniotic Fluid Index (cm)	17.2 ± 5.0
Status of Diabetes	
Diabetic	100 (50%)
Non-Diabetic	100 (50%)
Category of AFI	
Normal	104 (52%)
Polyhydramnios	1 (0.5%)
oligohydramnios	95 (47.5%)
Appearance of AFI	
Echo Free	170 (85%)
Low Level Internal Echo's	28 (14%)
Debris	2 (1%)

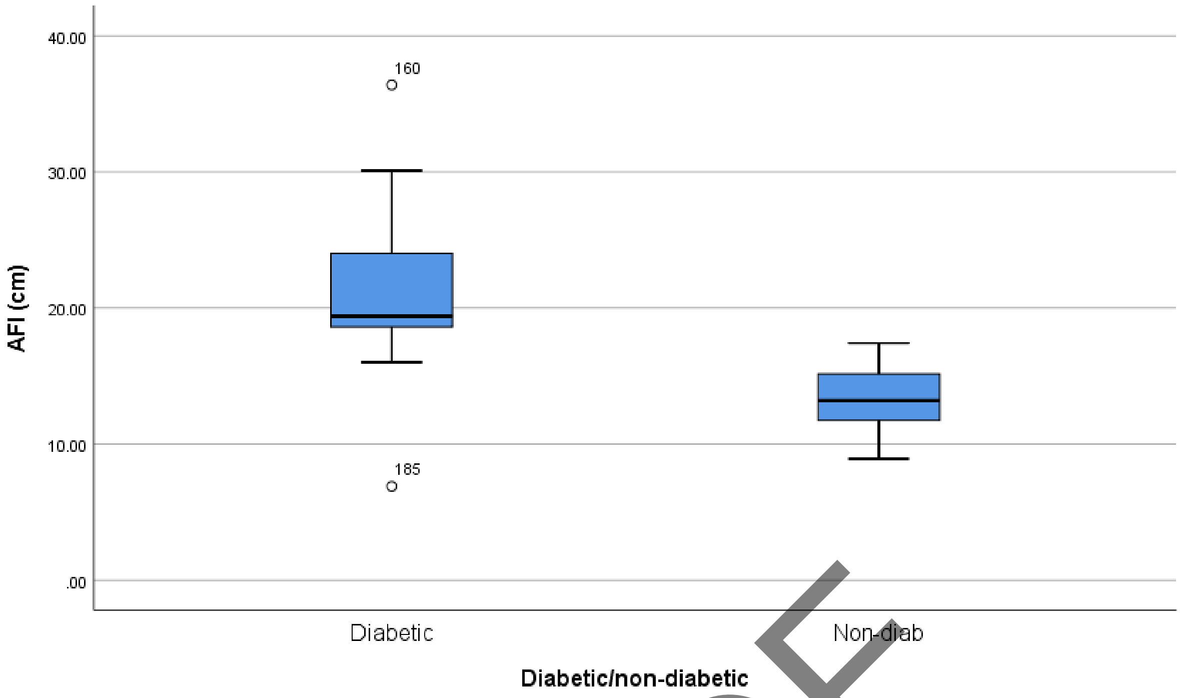

Figure 1. Box-Plot between diabetes and AFI shows significant differences between them

Table 2. Comparison of all the age, AFI, MVP, EFW, categories of AFI, and appearance of AFI with diabetes

		Diabetes		**P-value**
		Yes (n=100)	**No (n=100)**	
Age (years)		30.9 ± 4.5	26.2 ± 4.1	0.000
Amniotic Fluid Index (cm)		21.1 ± 3.9	13.2 ± 2.1	0.000
Maximum Vertical Pocket		7.61 ± 7.09	3.9 ± 1.1	0.000
Estimated Fetal Weight (grams)		1451.7 ± 770.6	1168.6 ± 865.5	0.015
Category of AFI	**Normal**	4 (2%)	100 (50%)	0.000
	Polyhydramnios	1 (0.5%)	0 (0%)	
	oligohydramnios	95 (47.5%)	0 (0%)	
Appearance of AFI	**Echo Free**	80 (40%)	90 (45.5%)	0.125
	Low Level Internal Echo's	19 (9.5%)	9 (4.5%)	
	Debris	1 (0.5%)	1 (0.5%)	

4. Discussion

Current research provides valuable insights into the relationship between diabetes and AFI and estimated fetal weight in pregnant females. Diabetic mothers exhibited a significantly higher mean AFI compared to non-diabetic mothers. Several factors could cause polyhydramnios in diabetic mothers: firstly, Diabetes can lead to altered fluid regulation in the body. Elevated blood glucose levels can result in increased urine production, which might subsequently affect amniotic fluid volume. Secondly, Diabetes is associated with vascular complications, and this could potentially affect the placental and fetal circulation, affecting amniotic fluid dynamics. Thirdly, the excretion of glucose in the urine due to poorly controlled diabetes might lead to increased urine production in the fetus, which could influence amniotic fluid levels.

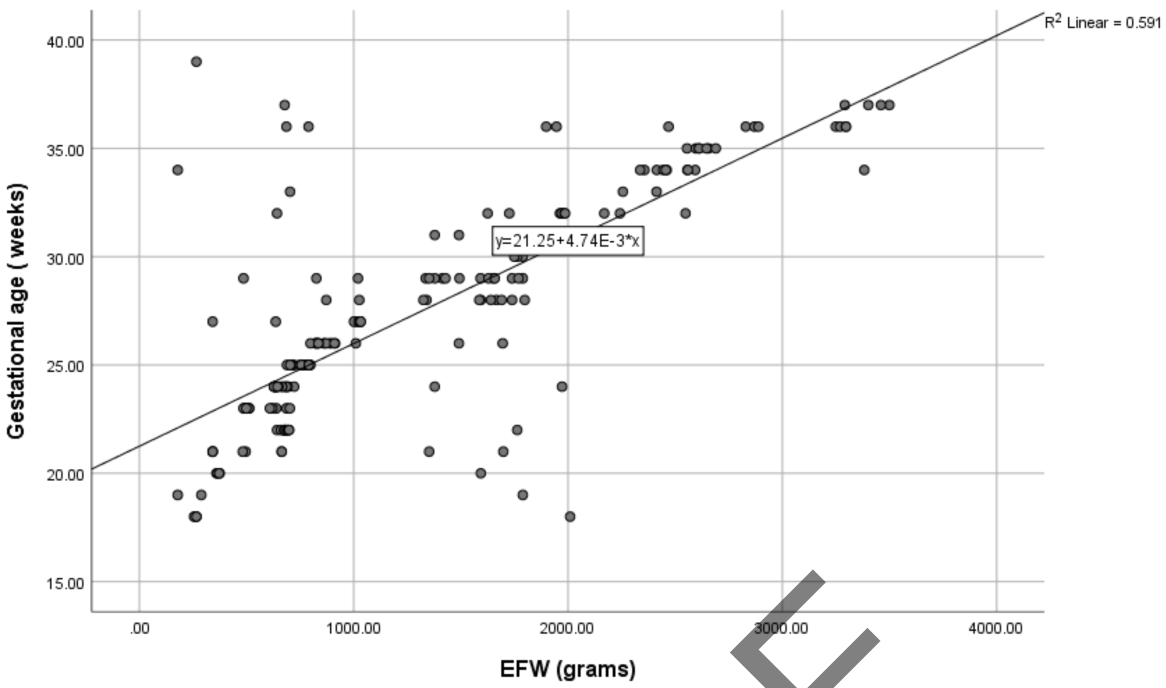

Figure 2. Scatter Plot between Gestational Age and Estimated Fetal Weights shows a significant correlation between them

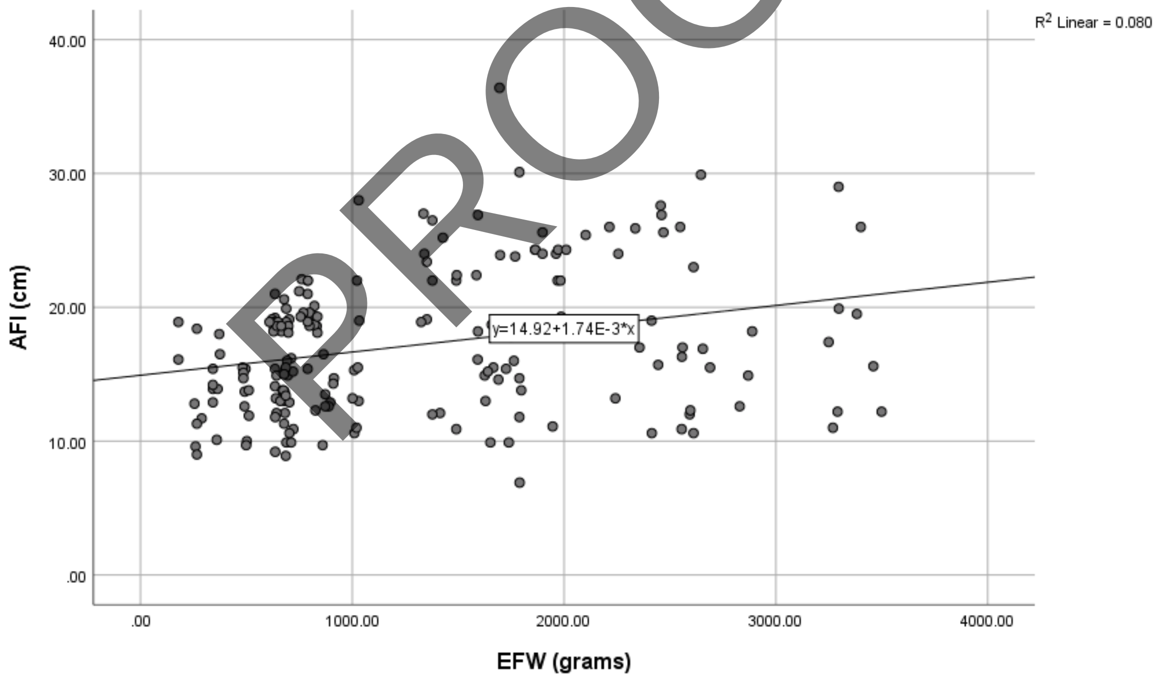

Figure 3. Scatter Plot between amniotic fluid index and estimated fetal weight shows insignificant difference between them

Jodi S did his research in 2000. In their study, the Mean age of females with diabetes was (27.5±5.9) and non-diabetics was (25.9±5.1). While in our study, the mean age was (28.62 ± 4.9). In their study, the mean AFI was significantly increased in the diabetes group (16.6 ± 5.0 cm) and (13.4 ± 3.5 cm) in the control group. Whereas in Our study the mean amniotic fluid index in the diabetic group was 21.19 and in the non-diabetic group was 13.2. In their study, maternal ages and neonatal birth weights were not significant between the two groups. While our study also shows insignificant fetal weight (P<.088). In their study the mean birth, weight with diabetes was (3540 ± 523) and in non-diabetics was (3379 ± 552). In our study mean birth, weight for the diabetic group was 1341.64, and for the non-diabetic group was 1372.53 [11].

Alexander Kofinas did his research in 2006; Normal pregnancies had a lower mean AFI than diabetes-related pregnancies did. Normal pregnancies had an AFI of 13.2 ± 0.3 cm, whereas diabetic patients had an AFI of 14.6 ±0.4 cm ($p = 0.002$). The mean EFW for the diabetic group was 2394.9 g (77.0%) and for the non-diabetic group 2063.3 g (56.0%) $p<0.0006$. Normal pregnancies and diabetes-complicated pregnancies both had a linear relationship between the AFI and the estimated fetal weight ($p< 0.0001$). While in our study the estimated fetal weight is not significant ($p< 0.088$) [8]

N. IDRIS did his research in 2010. In their study, they found out that polyhydramnios was directly related to poor diabetes control. Polyhydramnios was more common in hyperglycemic women. These women have high levels of HbA1c throughout their pregnancy with polyhydramnios, and levels of HbA1c were significantly higher in the preconception period and in the third trimester. In our study, we found similar results as in the diabetic group amount of AFI was significantly higher than non-diabetic group. In their study, they found out that women with clinically diagnosed diabetes had a significant value of polyhydramnios ($p=0.025$). Likewise, the results in our study also stated that women with `diabetes are more likely to develop polyhydramnios and the findings were significant statistically ($p=0.000$) [12].

Majid F et al did their research in 2022. In their study, they found out that, there was a strong correlation between GDM and maternal complications. They stated that increased levels of blood sugar concentration in maternal serum could cause polyhydramnios and macrosomia. In our research, we found out pregnant women with diabetes are more likely to develop polyhydramnios ($p=0.000$). However, unlike their study, we found that estimated fetal weight was insignificant in diabetic pregnant females ($p=0.088$) [13]. Lisa E Moore did his research in 2017. There, they found out that patients with diabetes had significantly higher rates of amniotic fluid as compared to other patients. The amount of polyhydramnios seen in the diabetic group was measurably huge ($p=0.0002$) in their study. Likewise, the amount of polyhydramnios calculated in our study was also statistically significant ($p=0.000$) [14]. Mathew J. Bicocca did his research in 2021. In their study, the AFI was fundamentally higher in the diabetic group likewise the results in our study also reported greater amounts of amniotic fluid index in the diabetic group. They included ultrasounds of 3rd trimester whereas we included ultrasounds of both 2nd and 3rd trimesters [15].

These findings underscore the importance of monitoring amniotic fluid levels, especially in diabetic pregnancies, and highlight potential implications for prenatal outcomes. The specific impact of amniotic fluid disorders on pregnancies with diabetes warrants further investigation to enhance clinical management strategies.

5. Conclusion

The study concluded that diabetes during pregnancy is associated with a significant increase in amniotic fluid levels, leading to a higher likelihood of polyhydramnios. However, diabetes does not appear to have a significant impact on the estimated fetal weight. A rise in AFI can be used as the earliest and most sensitive predictor for gestational diabetes

5.1. Limitations of the Study

The selection of the control group (non-diabetic pregnant women) may not adequately match the case group in terms of age, body mass index (BMI), and other confounding variables, which could influence the study outcomes.

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