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Differences in amniotic fluid patterns and fetal biometric parameters in third trimester pregnancies with and without diabetes

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Abstract

Objective. The amniotic fluid index (AFI) has been increasingly used in the assessment of fetal well-being. We conducted the study to evaluate and compare the amniotic fluid index in third trimester normal and diabetic human pregnancy and to assess the correlation between the AFI and the fetal biometric parameters.

Methods. Real-time ultrasound was performed to evaluate the AFI (four-quadrant technique), and to measure the biparietal diameter, head circumference, abdominal circumference, and femur length in 225 normal and 120 diabetic pregnant women from 27 to 42 weeks of gestation. Each patient was studied only once.

Results. AFI in normal pregnancies was less than that in diabetic pregnancies throughout the gestational ages studied (27–42 weeks). In normal pregnancy, the mean AFI was 14.0 cm at 27 weeks and decreased to 11.4 cm at 42 weeks ($r = 0.25$, $p = 0.0005$), whereas in diabetic pregnancies, the values remained stable throughout the gestational ages studied. There exist significant differences in AFI, estimated fetal weight, estimated fetal weight %, abdominal circumference, abdominal circumference %, and head circumference to abdominal circumference ratio between the two groups. In both normal and diabetic pregnancies, there is a positive correlation between the AFI and the percentile of abdominal circumference ($p < 0.0001$), and between the AFI and the percentile of estimated fetal weight ($p < 0.0001$).

Conclusion. This study provides gestational age-specific values of the AFI in normal and diabetic pregnancies. Diabetic pregnancy has greater AFI values than normal pregnancy between 27 and 42 weeks. The AFI correlates to the percentile of the estimated fetal weight and the abdominal circumference in both groups, suggesting that there may be a relationship between increased AFI and large for gestational age fetus independent of diabetes.

Keywords: *Pregnancy, amniotic fluid, diabetes, biometry*

Introduction

Estimation of amniotic fluid volume is an important part of fetal assessment, especially during the third trimester. Assessment of amniotic fluid volume by clinical means alone is difficult and inaccurate, but real-time sonography simplifies the evaluation and provides accurate amniotic fluid volume estimation. Phelan and colleagues were first to describe the amniotic fluid index (AFI) [1,2]. Subsequently, several investigators have reported values of the AFI for specific weeks of gestation [3–7].

The relationship between abnormal AFI and unfavorable perinatal outcome has been reported. Fetal conditions that are associated with oligohydramnios include intrauterine growth restriction, post maturity, and major fetal anomalies, commonly involving the fetal genitourinary tract [8–11]. Fetal conditions that are associated with hydramnios include maternal diabetes mellitus, major congenital anomalies such as open neural tube defect, upper gastrointestinal obstruction or malformations, congenital infections, and both immune and non-immune forms of hydrops fetalis [11–14]. For both oligohydramnios and hydramnios, there is increased perinatal morbidity and mortality. A significant number of pregnancies have evidence of hydramnios in the absence of any apparent pregnancy complications. The relationship between fetal size and amniotic fluid volume has been suggested [12,14].

The objective of this study was to evaluate the amniotic fluid index in the third trimester of normal and diabetic pregnancies and to evaluate the relationship between the AFI and fetal biometric parameters.

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Methods

We evaluated 225 normal pregnancies and 120 pregnancies complicated by diabetes at 27 to 42 weeks of gestation. All patients were referred to our unit for routine normal or diabetic prenatal ultrasound evaluation, and ultrasonic estimation of fetal weight between January 2001 and December 2004. All normal pregnant women had uncomplicated singleton pregnancies. Dating was established by accurate menstrual history confirmed by sonography prior to 20 weeks. Pregnancies complicated by diabetes consisted of patients with gestational ($n = 95$) or uncomplicated pregestational diabetes ($n = 25$). Patients with vasculopathy, renal disease, intrauterine growth restriction (IUGR), chronic hypertension and/or preeclampsia, were excluded. All patients with diabetes were delivered at no later than 40 weeks of gestation. The study design was cross-sectional and only the first sonographic evaluation from each patient was used. The study was approved by the institutional review board.

Ultrasound scans were performed with a real-time scanner with a 3.75 MHz curved-linear transducer. The amniotic fluid index was obtained by the four-quadrant technique described by Phelan et al. [1,2].

For each patient studied, the fetal biometric parameters measured were biparietal diameter, head circumference, abdominal circumference, and femur length. The estimated fetal weight, fetal weight percentile, and the various biometric ratios were assessed by means of computerized analysis based on previously reported fetal biometric studies [15].

Statistical analysis was performed by means of JMP Statistical Discovery Software for personal computers (SAS Institute Inc., Cary, NC, USA). The means of the AFI, abdominal circumference, abdominal circumference percentile, estimated fetal weight, fetal weight percentile, and head circumference–abdominal circumference ratio of the two groups were compared by *t*-test. Pearson's correlation analysis was used to evaluate the correlation between the AFI and the various biometric parameters.

Results

There is a significant inverse correlation; the AFI declines from an average of 14.0 cm at 27 weeks to 11.0 cm at 42 weeks ($p < 0.002$). There is no correlation between the AFI and gestational age; the AFI value remains stable from 27 to 40 weeks of gestational age. The mean AFI in normal pregnancies was less than the mean AFI in pregnancies complicated by diabetes throughout the gestational ages studied, and the difference became more prominent with advancing gestational age (Figure 1).

Table I presents the comparison of the means of the AFI and the biometric parameters between normal pregnancies and pregnancies complicated by diabetes. AFI in normal pregnancies was 13.2 ± 0.3 cm in comparison to 14.6 ± 0.4 cm in patients with diabetes ($p < 0.002$). As noted, significant differences exist between the two groups when the various biometric parameters are compared.

Figure 2 depicts the linear fitting of the abdominal circumference percentile against the AFI in normal pregnancies and Figure 3 in pregnancies complicated by diabetes. AFI increases with increasing values of abdominal circumference percentile ($p = 0.0001$). Figure 4 shows a significant positive linear relationship

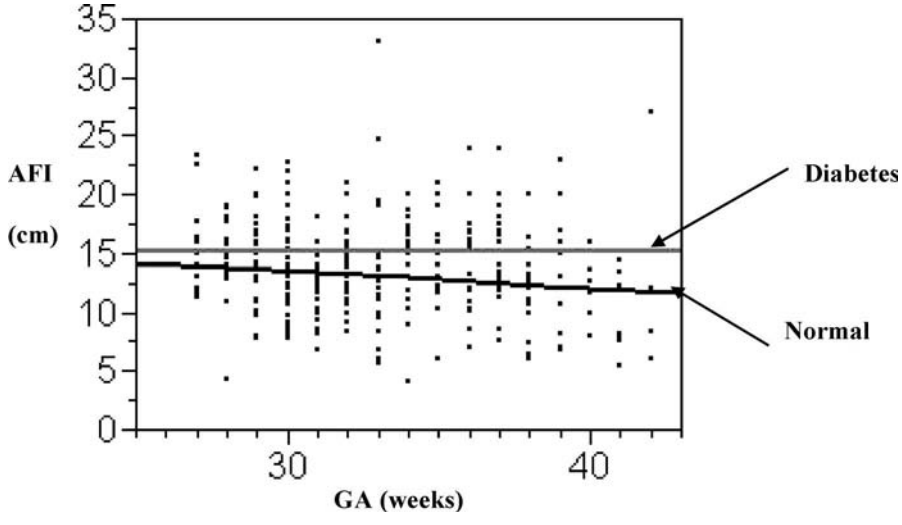

Figure 1. Concomitant plotting of AFI in normal pregnancies and in pregnancies with diabetes against gestational age. Note the different slopes.

between the estimated fetal weight percentile and the AFI in normal pregnancies and Figure 5 in pregnancies complicated by diabetes ($p = 0.0001$).

Discussion

The amniotic fluid index provides a semi quantitative analysis of the amniotic fluid volume. The technique is simple and highly reproducible. The intra-observer and inter-observer variations have been found to be small [3,16,17], and can relate to fetal movement [18].

This study provides gestational age-specific values of the AFI in normal pregnancies in the third trimester, which are in agreement with previous reports by Phelan et al. [2], Moore et al. [3], Jeng et al. [4], and Hallak et al. [5]. To our knowledge, this is the first report on the AFI curve of diabetic pregnancies during the 3rd trimester. As it becomes evident from the correlation analysis, the AFI of diabetic patients follows a different pattern than the AFI of normal patients. This finding may have significant implications in the clinical application of AFI measurements in fetal well-being assessment. It is important to note here that all diabetic patients were delivered at no later than 40 weeks of gestation and thus we cannot tell whether the AFI would remain stable or decline between 40 and 42 weeks.

Table I. Comparison of fetal biometric parameters in normal and diabetic pregnancies.

Parameter	Diabetes Mean (SE)	Normal Mean (SE)	*p* Value
AFI	14.6 cm (0.4)	13.2 cm (0.27)	0.002
EFW*	2394.9 g (77.0)	2063.3 g (56.0)	0.0006
EFW %	63.2 (2.4)	51.8 (1.8)	0.0002
AC	30.2 cm (0.3)	28.3 cm (0.3)	0.0001
AC %	65.8 (2.2)	54.4 (1.6)	0.0001
HC/AC**	1.05 (0.006)	1.09 (0.005)	0.0001

SE, standard error; AFI, amniotic fluid index; EFW, estimated fetal weight; AC, abdominal circumference; HC, head circumference. *Estimated fetal weight at time of ultrasound. **Head circumference to abdominal circumference ratio.

The production and regulation of amniotic fluid is a dynamic and complex process involving mainly fetal urine output, fetal swallowing, and fetal lung fluid flow [19]. Chamberlain et al. [12], and Varma et al. [14] described the possibility that amniotic fluid volume is related to fetal weight, but the mechanism of this observation is not understood. Three different theories [20] have been introduced to explain the possible interaction between maternal glycemic status and amniotic fluid volume: (1) maternal hyperglycemia induces fetal hyperglycemia resulting in osmotic diuresis when the fetal threshold for glucose is exceeded; (2) as glucose equilibrates across the placenta there is an isosmotic movement of fluid toward the fetal compartment with volume expansion and an increase in glomerular filtration rate leading to enhanced fetal urine output production; and (3) decreased fetal swallowing without concomitant change in fetal urination.

It has been speculated that hydramnios noted in pregnancies with diabetes is the result of osmotic diuresis secondary to fetal hyperglycemia and

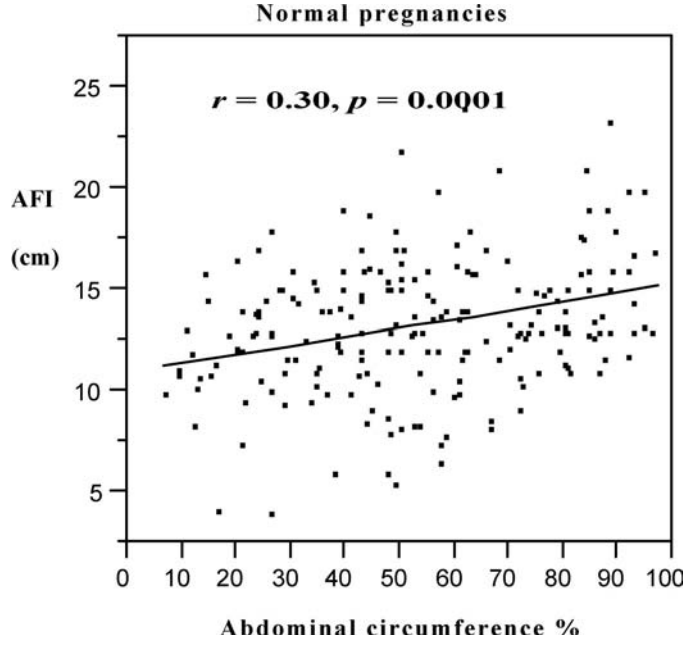

Figure 2. AFI plotted against abdominal circumference percentile in normal pregnancies. There is significant positive correlation.

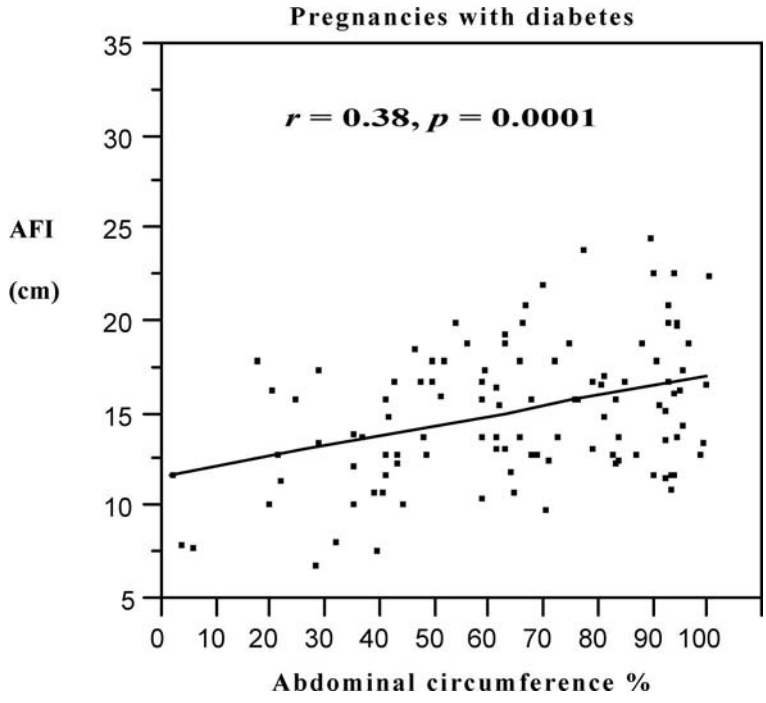

Figure 3. AFI plotted against abdominal circumference percentile in pregnancies with diabetes. There is significant positive correlation.

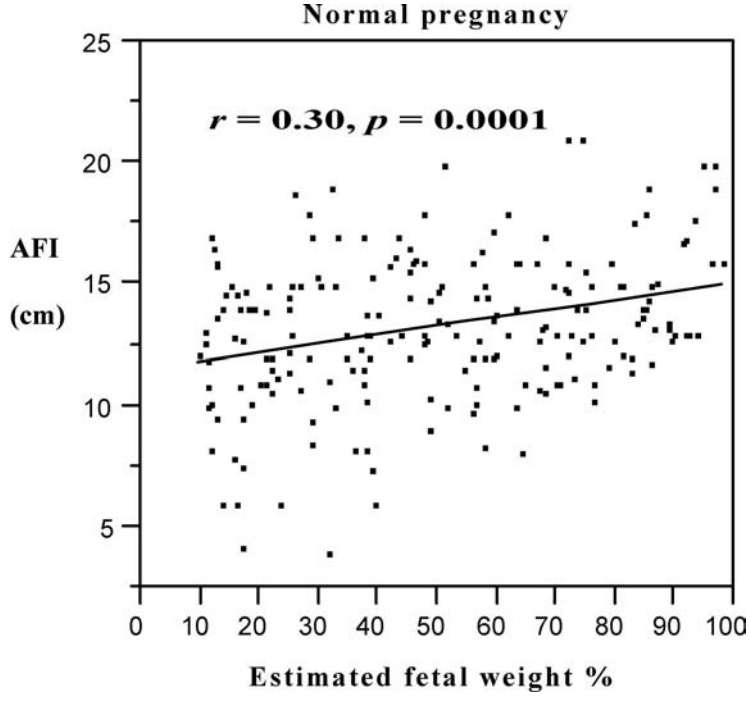

Figure 4. AFI plotted against estimated fetal weight percentile in normal pregnancies. Note the significant positive correlation.

glycosuria. However, the concentration of glucose and other solutes in amniotic fluid is not consistently related to amniotic fluid volume [21,22]. Fetuses of diabetic pregnancies spend more time breathing than fetuses of normal pregnancies [23]. We speculate that since by nature breathing and swallowing are mutually exclusive, increased time devoted to fetal breathing reduces the time that the fetus spends swallowing. Decreased swallowing activity may decrease in part the amount of amniotic fluid removed from the intra-amniotic space, which in turn causes increased amniotic fluid volume.

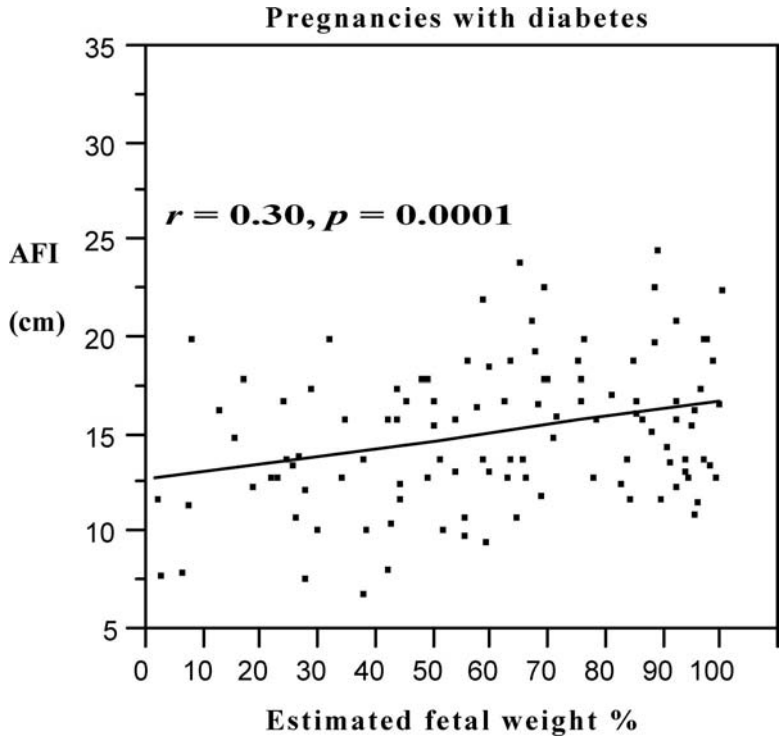

Figure 5. AFI plotted against estimated fetal weight percentile in pregnancies with diabetes. Note the significant positive correlation.

Diabetic patients have greater AFI, abdominal circumference, and estimated fetal weight than normal pregnant patients. As expected, the head circumference–abdominal circumference ratio is smaller in the diabetic group indicative of the diabetic type of asymmetrical growth.

Our findings confirm the higher incidence of increased amniotic fluid volume (hydramnios) and large for gestational age (macrosomia) in the diabetic patients. Interestingly, the AFI correlates to the percentile of the estimated fetal weight and the abdominal circumference in both diabetic and normal pregnancies. This suggests that there is a relationship between increased AFI and large fetal size during the third trimester for both diabetic and normal pregnancies. This relationship was identified in normal pregnancies before by means of AFI and deepest vertical amniotic fluid pocket [24,25]. It is of interest to note that regardless of the presence of diabetes, fetal size normalized for gestational age is in part responsible for the higher amniotic fluid volume in such patients.

In summary, this study suggests a correlation between the amniotic fluid volume (expressed as AFI) and the estimated fetal weight and abdominal circumference corrected for gestational age. Although, fetal weight variability alone cannot explain the presence of hydramnios in the apparently normal fetus, we suggest that this information is taken into account when patients are counseled for the potential risks of hydramnios.

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