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An Amniotic Fluid Index 5 cm Within 7 Days of Delivery in the Third Trimester Is Not Associated with Decreasing Umbilical Arterial pH and Base Excess

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OBJECTIVE: To determine if an amniotic fluid index (AFI) ≤ 5.0 cm within 7 days of delivery in the third trimester is associated with decreasing umbilical arterial pH and base excess.

STUDY DESIGN: Cases for this retrospective cohort study were all pregnancies 26 weeks with intact membranes and an AFI ≤ 5.0 cm within 7 days of delivery between 11/99 and 7/02. Multiple gestations, aneuploid, and anomalous fetuses were excluded. Controls with an AFI > 5.0 cm within 7 days of delivery were matched to each case within 1 week by gestational age. For a control group with a mean SD umbilical arterial pH of 7.260.07 and ± 0.05 , a sample size of 100 would have a power of 99% to detect a difference with a study group whose mean was 7.20. Data were compared using paired Student's *t*-test, Mann-Whitney, Fisher's exact, ² and risk ratios with 95% confidence intervals.

RESULTS: In all, 131 neonates with an AFI ≤ 5.0 cm were matched to 131 controls with an AFI > 5 cm. There was no difference in gestational age (37.63.0, 37.73.0 weeks) or birth weight (2897810, 2762788 g). There was no difference in umbilical artery pH (7.250.07, 7.260.07) or base excess (-3.322.59, -2.832.45 mmol/l), even in small for gestational age (SGA) infants in both groups. There was no difference in the number of SGA neonates, 5-minute Apgar < 7 , respiratory distress syndrome, necrotizing enterocolitis, or neurologic morbidity. Linear regression showed no correlation between AFI and either umbilical arterial pH ($r = -0.00047$, $SE = 0.001$, $p = 0.63$) or base excess ($r = -0.029$, $SE = 0.037$, $p = 0.428$).

CONCLUSION: An AFI ≤ 5.0 cm measured within 7 days of delivery in the third trimester is not associated with decreasing umbilical arterial pH and base excess. To determine if an amniotic fluid index (AFI) ≤ 5.0 cm within 7 days of delivery in the third trimester is associated with decreasing umbilical arterial pH and base excess.

INTRODUCTION

Traditionally, oligohydramnios has been considered a sign of potential fetal compromise and linked with an increased risk of perinatal morbidity and mortality.[1](#)[2](#)[3](#)[4](#)[5](#) In addition to fetal urologic anomalies, such as renal agenesis or urethral obstruction, and rupture of membranes, oligohydramnios can be caused by uteroplacental insufficiency. Maternal diseases that cause vascular injury such as chronic hypertension, pregestational diabetes mellitus, and collagen vascular diseases are associated with decreased fetal renal perfusion, as are medications such as indomethacin, which inhibits formation of prostacyclin and PGE₂, leading to decreased fetal renal blood flow and decreased fetal urine production. After 20 weeks gestation, amniotic fluid is predominately fetal urine, and when oligohydramnios is identified it is felt to be a marker of chronic uteroplacental insufficiency. In conditions of reduced blood flow, the fetus will shunt blood away from nonessential organs such as the kidneys in order to preserve blood flow to the brain, heart, and adrenal glands. This concept has been supported by Doppler velocimetry studies showing decreased renal arterial flow in fetuses with oligohydramnios.[6](#) Hypoxemia in fetal lambs has been shown to decrease fetal renal perfusion,[7](#) which is reflected in reduced urine output and reduction of amniotic fluid volume.[8](#)

The "gold standard" for determining amniotic fluid volume is amniocentesis with dye instillation.[9](#) The volume of amniotic fluid is determined from the concentration of dye after instillation. Since this involves an invasive procedure associated with a risk of complications, it is seldom if ever applied clinically, and we rely on noninvasive ultrasonographic methods to obtain an approximation of amniotic fluid volume. Although subjective assessment and the size of the largest vertical pocket have been used in the past, today the most widely used method to assess amniotic fluid volume is the amniotic fluid index (AFI). Gestational age tables giving percentiles for the AFI have been determined; however, measurements less than the fifth percentile have not been associated with increased perinatal morbidity and mortality.[10](#) Absolute measurements 5 cm at any gestational age have been linked with an increase in complications in the neonate, and although it has become standard practice to initiate antenatal testing and early delivery based on this finding, not all authors have found an isolated AFI 5 cm to be a marker for fetal compromise.[10](#)[11](#)[12](#) Some investigators have found oligohydramnios to be ominous only if accompanied by growth restriction[13](#) or severe fetal heart rate decelerations.[14](#) If an AFI 5 cm identifies the fetus with uteroplacental insufficiency, there should be an association with a decrease in umbilical arterial pH and base excess at the time of birth. The primary objective of this study was to determine if oligohydramnios, as defined by an AFI 5 cm, was associated with decreasing umbilical arterial pH and base excess.

MATERIALS AND METHODS

Cases for this retrospective cohort study were identified by searching the perinatology ultrasound and antenatal testing computerized databases at a single tertiary university hospital for AFI measurements 5 cm during the period from November 1999 to July 2002. The AFI was calculated as the sum of the largest vertical pocket in four quadrants as described by Phelan et al.[15](#) Color Doppler was used in the assessment of the AFI. Examinations were performed by experienced technicians or nurses supervised by a

perinatologist in the antenatal testing unit using the Acuson 128XP, ATL Ultramark 4 and 9, Siemens Elegra Advanced, Aloka 5500, or an Acuson Sequoia. All were high-risk pregnancies receiving antenatal testing, and were beyond 26 weeks gestation with intact membranes and an AFI measured within 7 days of delivery. Multiple gestations and fetuses/neonates with congenital anomalies or chromosomal abnormalities were excluded. Those with an AFI 5.0 cm were grouped together, and were matched 1:1 to the next delivery by gestational age within 1 week to a control group with an AFI >5 cm. All fetuses had continuous electronic fetal monitoring while in labor. Maternal and neonatal records were reviewed to obtain maternal age, gravidity, parity, gestational age at delivery, mode of delivery, birth weight, 5-minute Apgar score, umbilical arterial pH and base excess, neonatal length of stay, the presence of small for gestational age (SGA), respiratory distress syndrome, necrotizing enterocolitis, and neurologic morbidity (defined as intraventricular hemorrhage or neonatal seizures). For a control group with a meanSD umbilical arterial pH of 7.260.07 and =0.05, a sample size of 100 would have a power of 99% to detect a difference with a case group whose mean was 7.20, and a power of 86% to detect a difference if the case group mean was 7.23. If the group with an AFI 5 cm had a mean umbilical arterial pH of 7.20 or lower, our study has a 99% chance of detecting this difference. This arbitrary, small decrease would not be clinically significant, but would identify a correlation between the AFI and a decreasing umbilical arterial pH if it indeed existed.

Statistical analysis was performed with SPSS version 10.0 (SPSS Inc., Chicago, IL) and Stata version 7.0 (Stata Inc., College Station, TX). Paired Student's *t*-test, Fisher's exact, ², Mann-Whitney, and risk ratios with 95% confidence intervals were calculated where appropriate. Probability value of 0.05 was considered statistically significant.

RESULTS

In total, 131 euploid nonanomalous fetuses with intact membranes were identified with an AFI 5.0 cm within 7 days of delivery and were matched to 131 controls with an AFI >5 cm. Maternal demographics did not differ between the two groups by age, gravidity, parity or gestational age (table 1). The interval between AFI measurement and delivery was shorter for those with an AFI 5 cm likely due to labor inductions associated with this finding. Those with an AFI >5 cm had a significantly increased rate of cesarean deliveries due to an increase in active phase arrest; however, there was no difference in birth weights between the two groups. There was no difference in cesarean delivery for nonreassuring fetal status between the two groups. When the indications for antenatal testing were compared between the case and control groups, those with an AFI 5 cm were significantly more likely to be receiving antenatal testing for oligohydramnios and oligohydramnios combined with intrauterine growth restriction (IUGR) (table2). Those in the control group were significantly more likely to be receiving antenatal testing for chronic hypertension with diabetes and pre-eclampsia.

Table 1. Maternal Demographic Data for Women 26 Weeks with a Nonanomalous Euploid Fetus and an AFI Determined Within 7 Days of Delivery

	AFI 5 cm (n=131)	AFI >5 cm (n=131)	<i>p</i>
Age (meanSD, years)	25.76.9	27.37.4	0.07
Gravidity (median)	2	2	0.70
Parity (median)	1	1	0.92
Gestational age (weeks)	37.63.0	37.73.0	0.79
AFI (meanSD, cm)	3.01.5	10.74.0	<0.001
AFI to delivery interval (meanSD, days)	1.31.4	3.22.2	<0.001
Cesarean delivery	41 (31%)	57 (44%)	0.04
Arrest of labor	6 (4.6%)	18 (13%)	0.01
Latent phase arrest	1 (0.8%)	4 (3.1%)	0.18
Active phase arrest	5 (3.8%)	14 (10%)	0.03
Nonreassuring fetal status	8 (6.1%)	16 (12%)	0.09
Other	27 (21%)	23 (18%)	0.53

Table 2. Indications for Antenatal Testing

	AFI 5 cm (n=131)	AFI >5 cm (n=131)	<i>p</i>
Oligohydramnios	44 (33.6%)	13 (10.0%)	<0.0001*
IUGR	3 (2.3%)	11 (8.4%)	0.051
Oligohydramnios+IUGR	16 (12.2%)	2 (1.5%)	0.0009*
Chronic hypertension	7 (5.3%)	14 (10.7%)	0.11
Diabetes mellitus	19 (14.5%)	21 (16.0%)	0.73
Chronic hypertension+diabetes	0	6 (4.6%)	0.03*
Pre-eclampsia	7 (5.3%)	17 (13.0%)	0.03*
Postdates	25 (19.0%)	20 (15.3%)	0.41
Decreased fetal movement	4 (3.1%)	2 (1.5%)	0.68
History of fetal loss	1 (0.8%)	4 (3.1%)	0.37
Size<dates	1 (0.8%)	4 (3.1%)	0.37
Collagen vascular disease	0	5 (3.8%)	0.06
Vaginal bleeding	0	1 (0.8%)	1.0
Hemoglobinopathy	0	2 (1.5%)	0.5
Fetal arrhythmia	0	1 (0.8%)	1.0
Isoimmunization	0	1 (0.8%)	1.0
Maternal cardiovascular disease	0	2 (1.5%)	0.5
Other	4 (3.1%)	5 (3.8%)	1.0

The umbilical arterial pH and base excess were not significantly different between the groups (table 3). Having an AFI 5 cm within 7 days of delivery was not associated with a decrease in cord pH or base excess. There was no difference in cord gases between the groups when the SGA infants were analyzed separately, nor was a low AFI correlated with metabolic acidosis in either term or preterm

neonates. There was no difference in SGA infants, 5-minute Apgar score <7, respiratory distress syndrome, necrotizing enterocolitis, or neurologic morbidity between the two groups. When those cases with an AFI 5 cm within 2 days of delivery were compared to those with an AFI 5 cm within 3 to 7 days of delivery, no difference in umbilical arterial pH (7.260.07, 7.290.17, $p=0.18$) or base excess (-3.02.4, -1.82.7 mmol/l, $p=0.20$) was found. Linear regression showed no correlation between a decreasing AFI and decreasing umbilical arterial pH ($r=-0.00047$, $SE=0.001$, $p=0.635$) or base excess ($r=-0.029$, $SE=0.037$, $p=0.428$).

	AFI 5 cm (n=131)	AFI >5 cm (n=131)	p, RR (95% CI)
Birth weight (meanSD, g)	2897810	2762788	0.17
Neonatal length of stay (meanSD, days)	6.610.8	5.39.6	0.29
Neonatal length of stay 6 days	30	33	0.66
Cord pH (meanSD)	7.260.07	7.250.07	0.23
Cord pH <7.20	12/91 (13%)	21/112 (19%)	0.29
Cord pH <7.10	2/91 (2.2%)	2/112 (1.8%)	0.83
Cord base excess (meanSD, mmol/l)	-2.832.29	-3.532.67	0.07
SGA	32 (24%)	20 (15%)	0.06
			1.6 (0.97–2.6)
Cord pH for SGA infants (meanSD)	7.240.07	7.250.05	0.38
Cord base excess for SGA infants (meanSD, meq/l)	-2.812.56	-3.21+2.49	0.66
Term (37 weeks)	88 (67%)	93 (71%)	0.50
Average gestational age for term neonates (weeks, meanSD)	39.21.3	39.21.4	0.90
Cord pH for term neonates (meanSD)	7.260.07	7.250.06	0.47
Preterm (<37 weeks)	43 (33%)	38 (29%)	0.51
Average gestational age for preterm neonates (weeks, meanSD)	34.32.9	34.12.9	0.72
Cord pH for preterm infants (meanSD)	7.260.09	7.240.08	0.53
5 minute apgar <7	5 (3.8%)	6 (4.6%)	0.76
			0.83 (0.26–2.7)
Respiratory distress syndrome	11 (8.4%)	9 (6.9%)	0.64
			1.2 (0.52–2.9)
Necrotizing enterocolitis	2 (1.5%)	1 (0.8%)	0.56
			2.0 (0.18–21.8)
Neurologic morbidity	7 (5.3%)	4 (3.1%)	0.36

Table 3. Neonatal Outcomes Compared by AFI

COMMENTS

The reported increase in adverse perinatal outcomes associated with oligohydramnios has led to an almost uniform recommendation for delivery following this diagnosis in patients beyond 37 weeks gestation. This potential increase in perinatal morbidity and mortality is thought to result from umbilical cord compression and uteroplacental insufficiency. However, early reports of this association included fetuses with structural anomalies, most commonly of the urinary tract. Although a recent study found that antepartum oligohydramnios was associated with an increased incidence of stillbirth, nonreassuring fetal heart rate, admission to the neonatal intensive care

nursery, meconium aspiration syndrome, and neonatal death, these authors did not feel that either their results, or similar results reported by others, necessarily prove that antepartum oligohydramnios requires intervention. They felt that the use of the AFI to predict fetal well-being is complicated by the imprecise nature of its measurement, as well as by individual physician thresholds for pregnancy interventions.¹

Some authors have advocated the use of an AFI as part of a "fetal admission test", which when combined with an initial fetal heart rate monitor strip or the fetal response to acoustic stimulation could be used to triage patients to a low- or high-risk status.⁴ However, a study of 490 consecutive parturients admitted in labor found that an AFI between 0 and 20 cm could not accurately predict which parturients will have cesarean deliveries for fetal distress or be delivered of a newborn with a low Apgar score at 5 minutes.¹⁰ They found that both an AFI <fifth percentile for gestational age or 5 cm at any gestational age were poor predictors of adverse outcome for high-risk intrapartum patients and concluded that ultrasonographic assessment of amniotic fluid volume should not be undertaken in early labor because it does not accurately predict adverse outcome.

An increased risk of neonatal morbidity and acidosis would be expected to occur with a low AFI that results from uteroplacental insufficiency. Despite a large sample size with a 99% power to detect a very small decrease in umbilical artery pH, our study failed to support this association. A review of the literature on the association of an AFI 5 cm and fetal acidosis support the findings of our study. Casey et al.¹ found no increased incidence of severe neonatal acidemia (defined as umbilical artery pH <7.0) or seizures within the first 24 hours of life when 147 cases with an AFI 5.0 cm at 34 weeks were compared to controls with an AFI >5.0 cm. Similarly, Magann et al.¹¹ found no statistically significant difference in mean umbilical artery pH or incidence of pH <7.10 or 7.00 when 210 cases with an AFI 5.0 cm within 1 week of delivery were compared to controls with an AFI >5.0 cm. Using umbilical arterial pH thresholds of 7.15 and 7.00, Conway et al.¹² also found no difference in neonatal acidosis when 183 patients at term who underwent induction of labor secondary to AFI 5.0 cm were compared to controls with an AFI >5.0 cm admitted in spontaneous labor. Larson et al., using a threshold umbilical arterial pH of 7.20, found no difference in neonatal acidosis or mean umbilical artery pH when 51 subjects with an AFI 5.0 cm undergoing induction of labor with PGE₂ gel were compared to controls also undergoing induction of labor with PGE₂ gel but with an AFI >5.0 cm on admission.¹⁶ The only study to find an association between sonographically diagnosed oligohydramnios and neonatal acidosis defined acidosis as a scalp pH (rather than an umbilical artery pH) <7.20.¹⁴ When compared to patients with a reactive NST and an AFI >5.0 cm within 1 week of delivery, those with an AFI 5.0 cm and severe variable decelerations had a statistically significant increase in neonatal acidosis. This increased risk of acidosis did not persist in the absence of severe variable decelerations. A study of 100 unlabored women, who had ultrasound and amnio for fetal lung maturity with dye instillation measurement of amniotic fluid volume prior to an elective cesarean delivery, found that neither ultrasound nor dye-determined fluid volume assessments were predictive of a low umbilical artery pH at delivery.¹⁷ They could not identify any AFI from 0 to 18, single deepest pocket from 0 to 12, or dye-determined amniotic fluid volume 100 to 1900 ml, to differentiate newborns with an umbilical cord pH <7.0.

Current studies, including ours, have failed to show a consistent association between sonographically diagnosed oligohydramnios and neonatal morbidity. Even without an increase in neonatal morbidity, one would expect to see a drop in umbilical arterial pH and base excess in a fetus with chronic uteroplacental insufficiency severe enough to cause a low AFI. Much of current antenatal testing is based on this premise. The biophysical profile, one of the most commonly performed tests of fetal well-being, considers a decreased amniotic fluid assessment to be an indicator of long-term fetal compromise, as opposed to fetal movements that reflect the acute fetal

state. The AFI may not be a sensitive enough test to detect the fetus at risk for uteroplacental insufficiency for several reasons. The AFI is a two-dimensional representation of the true three-dimensional amniotic fluid pockets that are dispersed unequally throughout the amniotic cavity, and this measurement is changed by the presence of constant fetal movements and the position of loops of umbilical cord with resulting differences in fluid dispersion throughout the uterine cavity. The AFI is a reliable indicator of normal amniotic fluid volumes, but the sensitivity in two studies ranged from only 6 to 9% for those with oligohydramnios when compared to dye dilution volumes.^{9,18} Dildy et al.,¹⁹ when comparing the accuracy of the AFI with the dye-dilution technique, found that the AFI overestimated the actual volume by as much as 88.7% at lower amniotic fluid levels.

In summary, our study indicates that if delivered within 7 days of diagnosis, a third trimester AFI 5.0 cm is not associated with an increased risk of fetal metabolic acidosis, neonatal morbidity, or cesarean delivery for fetal distress. Although induction of labor in those patients with an AFI 5.0 cm did not increase the risk for cesarean delivery, there is no evidence that these fetuses were suffering from uteroplacental insufficiency and more likely to develop metabolic acidosis. The findings of this study support the conclusion of others who have reviewed the data on this subject that "evidence is accumulating that in the presence of an appropriate-for-gestational age fetus, with reassuring fetal well-being and the absence of maternal disease, oligohydramnios is not associated with an increased incidence of adverse perinatal outcome."²⁰ In the absence of deep variable fetal heart rate decelerations or severe IUGR, an AFI 5 cm may most commonly reflect an uncompromised fetus in utero. Given the poor ability of the AFI to correctly identify the fetus at risk for uteroplacental insufficiency it appears that intervening to deliver the fetus with an isolated AFI 5.0 cm at term should be reconsidered.

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