Editorial

Oligohydramnios: use and misuse in clinical management

D. M. SHERER and O. LANGER
Division of Maternal-Fetal Medicine, Department of Obstetrics and Gynecology, St. Luke's Roosevelt Hospital Center, Columbia University College of Physicians and Surgeons, New York, USA

THE PROBLEM

Following the observation that decreased amniotic fluid volume or oligohydramnios when it occurs with other risk factors is associated with increased perinatal morbidity and mortality, amniotic fluid volume measurements have become standard in fetal surveillance and in the evaluation of high-risk pregnancies. The finding of oligohydramnios in the clinical settings of fetal growth restriction, postdates pregnancy, or pregnancies complicated by maternal disease, may indicate increased risk for intrauterine fetal demise or neonatal morbidity and may, in such circumstances, be utilized as an indication for delivery. Significant controversies exist regarding the physiology of amniotic fluid volume, clinical methodologies in the assessment of amniotic fluid volume, and clinical management of pregnancies complicated by oligohydramnios. Nevertheless, upon observation of oligohydramnios in otherwise uncomplicated term gestations, delivery, irrespective of the presence of reassuring fetal evaluation and the absence of maternal disease, has become routine. In our assessment, this may represent overtreatment, exacting a price in maternal morbidity especially in terms of operative delivery for failed (and possibly non-indicated) inductions of labor. In this editorial, we discuss physiological dynamics and factors which may affect amniotic fluid volume, potential pitfalls in the sonographic assessment of amniotic fluid volume, the clinical significance of oligohydramnios, and the prediction of associated increased adverse perinatal outcome and the enigma of clinical management of isolated oligohydramnios at term.

PHYSIOLOGICAL DYNAMICS OF AMNIOTIC FLUID

The presence of amniotic fluid throughout gestation enables normal development of the fetal respiratory, gastrointestinal and urinary tracts, musculoskeletal system and continued fetal growth in a non-restricted, sterile and thermally controlled environment.

Numerous factors contribute to the formation and removal of amniotic fluid. Following keratinization of the fetal skin (slightly after mid-gestation), amniotic fluid is considered to be a product mainly of fetal urination which approximates 30% of fetal body weight daily, and at term ranges between 600 and 1200 mL/day.

Other contributions consist of:
1. tracheal secretions excreted during breathing episodes and ranging between 60 and 100 mL/kg/day fetal weight near term;
2. the intramembranous pathway which includes transfers between amniotic fluid and fetal blood perfusing the fetal surface of the placenta, fetal skin, and umbilical cord, reaching almost 400 mL/day at term;
3. the transmembranous pathway which involves direct exchange across the fetal membranes between amniotic fluid and maternal blood within the uterus. The net transmembranous movement of fluid in human pregnancies has not been estimated, yet recent studies suggest that under normal conditions this route conducts only 10 mL/day of fluid near term.

Removal of amniotic fluid throughout gestation results mainly from fetal swallowing. It has been estimated previously at between 200 and 1500 mL/day, and is currently considered to approximate between 20% and 25% of fetal body weight per day. Collectively, data demonstrate that the amount of fluid removal by fetal swallowing is significantly less than that produced by fetal urination. Furthermore, large amounts of fluid are secreted by the fetal lung in the latter half of gestation, further adding to the amniotic fluid volume. Nevertheless, the amniotic fluid volume remains in relative equilibrium. Recent studies suggest the intramembranous pathway is responsible for correcting these imbalances, contributing to the regulation of amniotic fluid volume with a net removal of between 200 and 500 mL/day from the amniotic cavity. Slight changes in intramembranous permeability can produce very large effects on intramembranous flux rates. For example, substances such as prostaglandins excreted by the fetal kidneys or lungs or released by the amnion or chorion which enter the amniotic fluid could potentially alter intramembranous permeability and directly affect amniotic fluid volume. Interestingly, this function of the intramembranous pathway may explain the observation that with upper
gastrointestinal tract obstruction in humans (no fetal swallowing), polyhydramnios develops in only 40% of cases. Similarly, in animal studies in which fetal swallowing was prevented, fetal urine output remained normal and amniotic fluid volume was not different from that of the controls after 2–3 weeks. Gilbert and Brac demonstrated that absorption through the intramembranous pathway was increased with ligation of the fetal esophagus. Regarding amniotic fluid turnover, late in gestation when amniotic fluid volume averages 700–800 mL, 1000 mL fluid flows into and out of the amniotic compartment daily.

Amniotic fluid volume is gestational-age dependent, is maintained within a normal range, appears highly regulated (although the precise regulation mechanism remains elusive), and peaks between 36 and 38 weeks' gestation, decreasing thereafter, or according to recent data (obtained by the dye-dilution technique) attaining maximum volume near term. The observed etiology of the relative reduction in amniotic fluid volume towards term and in uncomplicated post-term pregnancies remains unclear. Nevertheless, experimental and clinical studies support the theory that the properties of the fetal membranes are of paramount importance in the maintenance of amniotic fluid volume and composition of amniotic fluid. It is enticing therefore to consider that teleologically the fetus, by reducing amniotic fluid volume at advanced gestational ages, may contribute to the induction, or indirectly initiate, spontaneous uterine contractions (and subsequent labor) simply by virtue of amniotic fluid volume reduction. This proposed mechanism would in essence be similar to the observed increased uterine contractility observed following spontaneous or artificial rupture of membranes, or even amniocentesis remote from term. Established nomograms regarding amniotic fluid volume vs. gestational age have been constructed. Utilization of such nomograms enable application of more stringent gestational-age dependent criteria in detecting abnormal (either high or low) amniotic fluid volumes.

FACTORS WHICH MAY AFFECT AMNIOTIC FLUID VOLUME

Factors well established as affecting amniotic fluid volume include: the postmaturity syndrome; maternal disease, including hypertension, diabetes in pregnancy (especially poorly controlled); and auto-immune disorders; maternal medications (prostaglandin synthetase inhibitors); altitude; fetal anomalies (including immune and non-immune fetal hydrops); fetal weight (macrosomic and growth-restricted). Amniotic fluid volume is significantly affected by maternal hydration status. Sherer et al. in 1990 reported a severely dehydrated patient with oligohydramnios in whom massive intravenous maternal hydration was associated with sonographic confirmation of increasing amniotic fluid volume. Subsequent prospective studies confirmed this observation, noting significant increases in the amniotic fluid index (AFI) after oral or intravenous maternal hydration. Furthermore, in a prospective study, Flack et al. demonstrated that short-term maternal oral hydration significantly increased the AFI in women with third-trimester oligohydramnios (AFI ≤ 5 cm) but not those with normal amniotic fluid volume. Of note, these authors attributed the increase to improved uteroplacental perfusion and not to fetal urination as might have been expected. Other authors differ in this regard, and attribute increased amniotic fluid volume in response to acute maternal hydration to increased fetal urine output as demonstrated indirectly by increasing diameters of fetal pyelectasis in hydrated patients, and by sonographically measured hourly fetal urine production rate. Dosi et al. studied the effect of acute maternal hydration (2 L/2 h) with either intravenous isotonic fluid, hypotonic fluid or oral water upon the AFI in patients > 35 weeks' gestation with AFI values ≤ 5 cm. These authors concluded that maternal osmotic change, rather than maternal volume expansion, exhibited a more direct impact upon increasing amniotic fluid volume as assessed by AFI measurements obtained within 1 h following short-term acute hydration. Chandra et al. also confirmed that either oral or intravenous hydration may correct uncomplicated oligohydramnios, demonstrating that neither intake route appears to be advantageous over the other. Interestingly, the amount of intravenous hydration did not correlate with the frequency of AFI change (46.6% increase with intravenous volumes ≤ 2000 mL vs. 40% with volumes > 2500 mL) or with the magnitude of change (average 1.3 cm and 0.6 cm, respectively). Conversely, Wolman et al. recently demonstrated that, as might have been expected, fasting may reduce the AFI, with a significant difference in the AFI in 22 patients who did, vs. 25 patients who did not, fast (11.7 cm vs. 15.4 cm, respectively). Of note, after 1 week there was no difference in the AFI between the two groups.

Despite the recognized association between maternal hydration status and amniotic fluid volume as assessed sonographically, it is surprising that to our knowledge strict, uniform, pre-examination maternal hydration status criteria have not been suggested, established or implemented.

Petrikovsky et al. demonstrated that fetal vibroacoustic stimulation induces an increase in fetal swallowing activity which may result in a diminution of amniotic fluid volume. Results of this study suggest that the AFI should be assessed before vibroacoustic stimulation is applied, and that caution should be exercised if vibroacoustic stimulation is to be utilized in the presence of low amniotic fluid volume. Brost et al., in a prospective study before and after attempted external cephalic version, assessed the affect of fetal presentation upon the AFI. These authors concluded that successful conversion from a breech to a cephalic presentation resulted in a significant increase in the AFI, and suggested that this should be considered when a breech-presenting fetus with a low normal AFI is evaluated. Interestingly, maternal smoking appears to affect neither amniotic fluid volume nor fetal urine output.

SONOGRAPHIC MODALITIES TO ASSESS AMNIOTIC FLUID VOLUME

The dye-dilution test is considered the gold standard in the assessment of amniotic fluid volume against which all other prenatal diagnostic methods should be compared. Unfortunately this modality is invasive, entailing amniocentesis, the complications of which may be higher in association with decreased amniotic fluid volumes.
All current sonographic methods of amniotic fluid assessment are adversely affected by virtue of the two-dimensional nature of real-time ultrasound representation of the three-dimensional aspects of amniotic fluid pockets dispersed unequally throughout the amniotic cavity. Precise sonographic assessment of the amniotic fluid volume may also be further impaired by the presence of a constantly active fetus and loops of umbilical cord in the amniotic fluid cavity, and the resulting differences in fluid dispersion throughout the amniotic cavity.

Readers of this Journal are undoubtedly familiar with the various reported sonographic modalities to assess amniotic fluid volume, which include: (1) single vertical pocket, (2) two-diameter pocket, and (3) amniotic fluid index (AFI). The number of sonographic modalities applied to assess amniotic fluid volume reflect the inaccuracies inherent in each of these modalities. Further complicating the issue of amniotic fluid volume assessments are the implications of various cut-off threshold points in the diagnosis of abnormally low amniotic fluid levels, which have been suggested regarding each of these various techniques.

Dildy et al. compared the accuracy of clinical ultrasound techniques of amniotic fluid volume assessment with dye-dilution technique assessments. These authors reported that the AFI overestimated the actual volume by as much as 88.7% at lower amniotic fluid volume levels and underestimated the actual volume by as much as 53.9% at higher amniotic fluid volumes. Similarly, Magaan et al. in a dye-dilution controlled study demonstrated that although the two-diameter pocket method was significantly more accurate in detecting oligohydramnios, neither operator experience nor sono- graphic technique (largest vertical pocket, AFI or two-diameter pocket method), greatly affected the accuracy of ultrasound estimates of amniotic fluid volume.

Also in a dye-dilution controlled study, Chauhan et al., in addition to the various described measurement techniques, described mathematical models to correlate AFI measurement with amniotic fluid volume, enhancing the detection rate of oligohydramnios. Recognizing the limited correlation between AFI and the two-dimensional area of amniotic fluid, Mann et al. recently applied the bladder volume instrument (utilizing a rotating 2-MHz transducer, a computer-defined fluid interface and computer integration of 12 cross-sectional images) to calculate a three-dimensional amniotic fluid volume. These authors demonstrated that one AFI cm was equivalent to 50 mL amniotic fluid, and was not affected by gestational age. As expected, the three-dimensional amniotic fluid volume assessment demonstrated a parabolic pattern throughout gestation and significantly correlated with previously established gestational-age related changes in amniotic fluid volume.

Interestingly, Del Valle et al. demonstrated that AFI values obtained with either sector or convex-array transducers are reliable (correlating well with values obtained with the linear transducer).

Finally, transvaginal ultrasound has been applied to depict the amniotic fluid volume potentially located in the forewaters, a location suboptimally depicted by transabdominal sonography, in patients ≥ 37 weeks’ gestation with either oligohydramnios or AFI > 5 cm. No significant difference was noted between the mean forewater measurement of patients with oligohydramnios vs. controls (0.2 ± 0.1 and 0.4 ± 0.1 cm, respectively). Furthermore, various permutations of the AFI, which included sonographic assessment of the forewaters, did not impact on the diagnosis of oligohydramnios.

POTENTIAL PITFALLS IN THE SONOGRAPHIC ASSESSMENT OF AMNIOTIC FLUID VOLUME

The AFI and single deepest pocket assessments are significantly sensitive to the abdominal pressure applied by the sonographer. Flack et al. demonstrated that when compared with medium pressure, low pressure results in a 13% increase in the AFI, vs. a 21% decrease in the AFI with high pressure. Furthermore, measurements obtained at the lowest pressure that will prevent image fallout will result in the highest AFI values and the lowest intraobserver variability.

Following the initial report of Rutherford et al. stating that fetal movements could alter the size and location of amniotic fluid pockets, Wax et al. assessed the effect of fetal movement upon the AFI. The mean change in matched pre- and postmovement AFI values following three discrete episodes of fetal movements was statistically significant at 2.5 ± 0.2 cm. However, this finding lacked clinical significance as determined by the intraobserver and interobserver variation of the four-quadrant technique. The authors concluded that the significant change in the AFI assessments associated with fetal movements is an artifact of the measurement’s intrinsic variability and should not be considered of clinical consequence in the hands of reliable examiners.

Following the original description of the AFI, in which this question was not addressed, Rutherford et al. reported that the umbilical cord or a fetal extremity may traverse a measured pocket of amniotic fluid. It is now clear, however, that many sonographers prefer to include only pockets entirely devoid of umbilical cord or extremities. Subsequently, Sadovsky et al. reported a decreased perinatal risk if cases with an AFI < 5 cm included a cord-containing pocket of amniotic fluid > 5 cm, suggesting a reduced need for intervention with the latter.

Infrequently, for as yet undetermined reasons, amniotic fluid may appear echogenic, containing dense ‘free-floating’ particles resulting in the pockets of fluid available for measurement being considerably less clear. Although earlier studies considered this to be suggestive of the presence of meconium-stained amniotic fluid, a number of subsequent prospective studies have negated this sonographic finding as a predictor of meconium. Nevertheless, in the presence of echogenic amniotic fluid it may be difficult to ascertain the interface between amniotic fluid/membranes and uterine wall, resulting in underassessment of the true amniotic fluid volume.

Initially, it was considered by many that the application of color Doppler imaging would enhance detection of oligohydramnios by virtue of avoiding incorrect inclusion of sonolucent areas of umbilical cord inadvertently considered as amniotic fluid. In line with this hypothesis, Bianco et al. reported that the application of color Doppler imaging resulted
in significantly lower amniotic fluid volume estimation by ultrasound. Specifically, these authors reported that the AFI is decreased by 20% by using color Doppler imaging.34

Recently, Magaan et al.53 reported amniotic fluid volume assessments (AFI and single-pocket techniques) with and without concurrent color Doppler imaging, followed by amniocentesis and dye-dilution calculated volumes. They concluded that the concurrent use of color Doppler imaging with AFI measurements leads to overdiagnosis of oligohydramnios. However, surprisingly, when the diagnosis of low fluid volume with and without color Doppler imaging was correlated with dye-determined volumes, the application of color Doppler imaging did not, in fact, enhance detection of true oligohydramnios. Of specific concern was the finding that with color Doppler imaging, nine of 42 women (21%) with normal amniotic fluid volume were diagnosed as having low fluid volume.53 This study supported the concept that AFI and single-deepest pocket (without color Doppler imaging) perform similarly, yet both are weak indicators of abnormal amniotic fluid volumes53.

OLIGOHYDRAMNIOS: DEFINITION AND SONOGRAPHIC THRESHOLDS

Oligohydramnios or decreased amniotic fluid volume is extremely poorly defined yet is often acted upon clinically, even when occurring as an isolated finding. Utilizing precise dye-dilution techniques, varying definitions of 200 and 500 mL have been applied34,35. A meta-analysis including 12 studies of either direct or dye measurement suggested a cut-off of 318 mL for oligohydramnios6. Cut-off criteria for oligohydramnios according to various sonographic volume assessment techniques are:

1. single vertical pocket; definitions range between 0.5 cm54, < 1.0 cm13, < 2 cm51, and < 3 cm56.
2. two-diameter pocket; vertical × horizontal < 15 cm34.
3. AFI technique; definitions of oligohydramnios include < 5 cm (which represents < 1st centile75, < 5th centile for gestational age (which translates into an AFI value of between 7.1 and 9.7 cm), < 5 cm54, < 7 cm47), and < 8 cm56,59. Others have considered AFI > 5 and < 10 cm as ‘borderline’ in 60.

Moore and Cayle9 reported a wider variation in AFI values in association with oligohydramnios and as a result advocate averaging three AFI values for amniotic fluid volumes < 10 cm. Although a number of studies note that the AFI closely relates to the amniotic fluid volume based on dye-dilution studies, as mentioned earlier, Dildy et al.39 reported that the AFI overestimated the actual volume by as much as 88.7% at lower volumes. Similarly, Chauhan et al.61 compared semiquantitative methods (AFI and two-diameter pocket assessment) with amniotic fluid volume assessments by dye-dilution at amniocentesis, again demonstrating a poor correlation. These authors concluded that for any specific AFI or two-diameter amniotic fluid pocket assessment, the range of the 95% confidence intervals is so wide that sonographic assessment is not a reasonable reflection of the actual amniotic fluid volume61. Magaan et al.34 reported a sensitivity of 6.7% in predicting true oligohydramnios (< 500 mL). Subsequently, Magaan et al.62 studied 179 women with singleton gestations assessed with sequential ultrasound estimations of amniotic fluid volume by AFI and single deepest pocket (without color Doppler imaging) in the presence of fetal urine output in this clinical picture may result from decreased fetal swallowing in the presence of oligohydramnios due to less available amniotic fluid67. Nevertheless, as yet undetermined and possibly of clinical significance is the not uncommon documentation of a full fetal bladder in the presence of oligohydramnios (Figure 1). To our knowledge, to date no study has evaluated whether inclusion of this measurable ‘pocket’ of what will inevitably, upon fetal urination, become amniotic fluid, would or would not affect subsequent AFI measurement. Yet it remains logical to believe that if a repeat AFI measurement were performed subsequent to fetal urination, the AFI would be increased and otherwise non-induced inductions of labor due to oligohydramnios might be avoided in these circumstances. Furthermore, it is logical to infer that in the presence of fetal urine production (as evident by a palpated fetal bladder), renal blood perfusion is not impaired. This finding of a visualized fetal bladder, if supported by normal Doppler velocimetry indices of the umbilical artery (reflecting normal placental resistance), would suggest that placental insufficiency would be an unlikely explanation for the observed decreased amniotic fluid volume in an appropriate-for-gestational age fetus.

CLINICAL SIGNIFICANCE OF OLIGOHYDRAMNIOS

Historically, oligohydramnios has been associated with an increased incidence of adverse perinatal outcome13,34, possibly due to an increase in umbilical cord compression, uteroplacental insufficiency, or an increased incidence of meconium-stained
amniotic fluid (and its inherent risks of meconium aspiration syndrome)\textsuperscript{68}. This reported increased incidence of adverse perinatal outcome has led to an almost uniform recommendation for delivery following the diagnosis of oligohydramnios, at least of patients > 37 weeks’ gestation. Clearly, original reports of this association included fetuses with structural anomalies (most commonly of the urinary tract), small-for-gestational age and growth-restricted fetuses, postmaturity syndrome, and fetuses of mothers with various underlying medical conditions mentioned previously which may affect amniotic fluid volume\textsuperscript{13,14,66,68,69}. Furthermore, oligohydramnios may be a transient finding. Lagrew \textit{et al.}\textsuperscript{70} in 1992 reported of patients > 37 weeks’ gestation. Clearly, original reports of this association included fetuses with structural anomalies (most commonly of the urinary tract), small-for-gestational age and growth-restricted fetuses, postmaturity syndrome, and fetuses of mothers with various underlying medical conditions mentioned previously which may affect amniotic fluid volume\textsuperscript{13,14,66,68,69}. Furthermore, oligohydramnios may be a transient finding. Lagrew \textit{et al.}\textsuperscript{70} in 1992 repeated AFI assessments of patients 3–4 days after values ≤ 5 cm had been observed. Of two hundred and forty-eight with AFI values ≤ 5 cm, the majority were subsequently delivered. However, 41% of undelivered patients had a normal or low normal repeat AFI upon follow-up\textsuperscript{70}. Unfortunately, no information was forwarded regarding maternal or neonatal outcomes of patients delivered immediately, those with resolution of oligohydramnios or those with continuing oligohydramnios\textsuperscript{70}. These authors concluded that in patients < 41 weeks’ gestation with normal AFI values, a repeat AFI assessment is not necessary for 7 days. In contrast, due to concerns of uteroplacental insufficiency in post-term patients and the potential relatively rapid decrease of amniotic fluid volume that may occur in this clinical condition, twice-weekly amniotic fluid volume assessments are uniformly practiced\textsuperscript{12,70–74}. Nevertheless, while induction of labor of post-term patients with oligohydramnios (AFI ≤ 5 cm or no vertical pocket > 2 cm) is considered standard care, adherence to this practice clearly results in subsequent increases in labor complications and the incidence of operative delivery potentially without significantly improving outcome\textsuperscript{75–77}.

Doppler velocimetry has assisted management of pregnancies complicated by oligohydramnios. Carroll and Bruner\textsuperscript{78} retrospectively assessed pregnancies complicated by oligohydramnios evaluated by Doppler velocimetry of the umbilical artery. Patients with ruptured membranes and congenital anomalies were excluded. Seventy-six subjects were included in the study. Forty-six patients had normal systolic/diastolic ratios and 17 (37%) were associated with unidentifiable perinatal morbidity. When prematurity due to delivery for the sole indication of oligohydramnios was excluded, morbidity occurred in five (11%) patients. Conversely, of the 30 patients with abnormal Doppler velocimetry, 80% sustained adverse perinatal outcomes\textsuperscript{78}. These authors concluded that pregnancies with oligohydramnios and normal umbilical artery Doppler velocimetry were significantly less likely to exhibit abnormal perinatal outcome compared to those with abnormal Doppler velocimetry. Furthermore, these data suggest that avoiding intervention in pregnancies with oligohydramnios and normal umbilical artery Doppler velocimetry may decrease iatrogenic morbidity due to prematurity by as much as 26%\textsuperscript{78}.

Stipulations for effecting delivery for patients at term with isolated oligohydramnios therefore appear to have been derived from studies including extremely heterogeneous groups of patients. To us it is entirely unclear whether this practice is appropriate for patients at term with isolated oligohydramnios, i.e. in the presence of an appropriate-for-gestational age, non-compromised fetus in the absence of maternal disease.

\section*{AMNIOTIC FLUID VOLUME AS A PREDICTOR OF PERINATAL OUTCOME}

Amniotic fluid volume assessment has been suggested by numerous authors as an intrapartum screening tool for women admitted in early labor. Significant recent literature supports the association of an increased incidence of adverse perinatal outcome and oligohydramnios\textsuperscript{79–81}. Chauhan\textsuperscript{79} \textit{et al.}, in a meta-analysis of 18 reports describing 10,551 patients, demonstrated that an antepartum or intrapartum AFI ≤ 5 cm is associated with a significantly increased risk of Cesarean delivery for ‘fetal distress’ and a low Apgar score at 5 min. Unfortunately this review, like many other such publications
Regarding the association of oligohydramnios and subsequent perinatal outcome, did not randomize, stratify or control patients according to essential entry criteria which may affect amniotic fluid volume. These include: maternal hydration status, absence of maternal disease, fetal or neonatal weight, and status of amniotic membranes (ruptured or intact). In addition the meta-analysis did not include precise neonatal outcome parameters (umbilical artery blood gases) and only one of the assessed studies included randomization of knowledge of AFI status of patients in labor\textsuperscript{80}. At least intuitively, it appears inappropriate to extrapolate such data regarding intrapartum patients to the management of those patients not in labor at term with isolated oligohydramnios.

Similarly, Casey et al.\textsuperscript{81} retrospectively analyzed 6423 patients undergoing ‘clinically indicated’ (rather than routine) antepartum ultrasound at ≥34 weeks’ gestation defined by an AFI of < 5 cm. Oligohydramnios complicated 2.3% of the gestations and was significantly associated with an increase in labor induction, still birth, non-reassuring fetal heart rate, admission to the neonatal intensive care unit, meconium aspiration syndrome and neonatal death. However, due to the study design (including only clinically indicated studies) selection bias may have been introduced and may have contributed to observed results\textsuperscript{81}. Interestingly, birth weights were significantly less in infants with oligohydramnios than in those with AFI values ≥ 5 cm. The proportion of low birth-weight infants (<2500 g) was significantly increased in the presence of oligohydramnios, findings which have also been confirmed by other authors\textsuperscript{67,71,81}. A significantly higher incidence of congenital syndromes was diagnosed in the oligohydramnios group. Of specific interest was the fact that if infants with major malformations were excluded, admissions to the neonatal intensive care unit, respiratory distress and neonatal deaths were no longer significantly associated with oligohydramnios. Despite the above results these authors acknowledge that these results do not necessarily prove that antepartum oligohydramnios requires intervention\textsuperscript{81}.

Conversely, Magaan et al.\textsuperscript{82} evaluated amniotic fluid volumes in 1001 patients receiving antepartum fetal testing. Oligohydramnios defined by an AFI ≤ 5 cm occurred in approximately 20% of patients and was not associated with an increase in the incidence of non-reactive non-stress tests, meconium-stained amniotic fluid, Cesarean delivery for fetal distress, low Apgar scores, or infants with cord pH levels of <7.\textsuperscript{10,82} Accordingly, the authors concluded that the AFI was a poor diagnostic test with which to determine whether a patient is at increased risk for an adverse perinatal outcome\textsuperscript{82}. Regarding the significance of amniotic fluid volume in patients with pregnancies complicated by severe pre-eclampsia, Schucker et al.\textsuperscript{83} retrospectively reviewed records of 136 such women managed conservatively for at least 48 h. They reported that for women with severe pre-eclampsia remote from term, an AFI of ≤ 5 cm, although lacking sensitivity, is predictive of fetal growth restriction. However, no association was observed between the AFI status and frequency of Cesarean delivery for fetal distress or non-reassuring fetal testing\textsuperscript{83}. In a study designed to assess the performance of intrapartum AFI for predicting fetal acidemia, Chauhan et al.\textsuperscript{84} assessed data obtained from 256 patients at ≥37 weeks’ gestation which indicated that the mean intrapartum AFI among 12 newborns with respiratory acidosis and 26 with metabolic acidosis was significantly lower than the mean index in 218 newborns without fetal acidemia. Despite the differences in the mean intrapartum AFI in the three groups analyzed, receiver operator characteristic curves indicated that an intrapartum AFI alone was a poor test for predicting acidosis (respiratory or metabolic) in the neonate\textsuperscript{84}. Rainford et al.\textsuperscript{85} assessed pregnancy outcomes of 232 women at ≥37 weeks’ gestation with AFI assessments performed within 4 days of delivery. Of the study group, 44 (19%) had an AFI ≤ 5 cm. The authors reported no difference in the operative delivery rate for non-reassuring fetal heart rate tracings, rates of neonatal intensive care unit admissions or 5-min Apgar scores <7, between patients with normal amniotic fluid volumes or those with oligohydramnios. Patients with normal AFI values had a significantly lower labor induction rate (96 (51%) vs. 42 (98%)) and a significantly higher rate of meconium-stained amniotic fluid (65 (35%) vs. 7 (16%)) than those with a lower AFI\textsuperscript{85}.

THE ENIGMA OF ISOLATED OLIGOHYDRAMNIOS

In a recent retrospective analysis, Kreiser et al.\textsuperscript{86} assessed perinatal outcomes of 150 low-risk pregnancies at ≥30 weeks’ gestation complicated by isolated oligohydramnios (AFI ≤ 5 or > 5 cm but < 2.5th centile for gestational age). Cases complicated by preterm rupture of membranes, insulin requiring diabetes mellitus, pre-eclampsia, confirmed fetal growth restriction, or severe systemic maternal disease were excluded. The outcomes of 57 pregnancies with AFI ≤ 5 cm were compared with those of 93 pregnancies with AFI > 5 cm but < 2.5th centile (borderline AFI). There were no significant differences between the pregnancies with respect to labor induction for an abnormal non-stress test, overall Cesarean deliveries for fetal heart rate abnormalities, overall presence of meconium and Apgar score <7 at 5 min\textsuperscript{86}. There were no perinatal deaths in either group. Antepartum variable decelerations of the fetal heart rate were more common with AFI ≤ 5 cm compared to those with AFI > 5 cm but < 2.5th centile (63.1% vs. 45.1%; \textit{P} = 0.007). The authors concluded that with antepartum monitoring (one to three times weekly non-stress test and AFI), perinatal outcome in low-risk pregnancies with isolated oligohydramnios appears to be good\textsuperscript{86}.

Conway et al.\textsuperscript{87} in a controlled trial assessed the hypothesis that isolated oligohydramnios in the otherwise normal term pregnancy does not indicate fetal compromise. One hundred and eighty-three women undergoing induction of labor for isolated oligohydramnios (AFI < 5 cm) between 37 and 41\textsuperscript{46} weeks’ gestation, were matched to 183 women presenting in spontaneous labor with normal AFI measurements by gestational age and parity upon admission. Patients with pregnancies complicated by hypertension, diabetes, fetal anomalies or suspected fetal growth restriction were excluded. The groups did not differ significantly in gestational age (40.8 ± 0.1 weeks vs. 40.2 ± 0.1 weeks; \textit{P} = 0.2), ethnic distribution or parity. The mean AFI on admission was 3.1 cm in the oligohydramnios group (range, 1.0–4.9 cm) and 7.1 cm in the control group (range, 5.0–18 cm; \textit{P} < 0.001). In
Table 1 Infant characteristics and outcome in patients with isolated oligohydramnios (AFI < 5.0) who underwent induction of labor versus control group of patients with normal AFI (AFI ≥ 5.0) presenting in spontaneous labor. (From Conway et al.86 with permission.)

<table>
<thead>
<tr>
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<th>AFI &lt; 5.0 (n = 183)</th>
<th>AFI ≥ 5.0 (n = 183)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight (g, mean (SEM))</td>
<td>3398 (34)</td>
<td>3428 (35)</td>
<td>NS</td>
</tr>
<tr>
<td>Ponderal index (mean (SEM))</td>
<td>2.48 (0.02)</td>
<td>2.51 (0.02)</td>
<td>NS</td>
</tr>
<tr>
<td>pH &lt; 7.15 (%)</td>
<td>10.4</td>
<td>7.1</td>
<td>NS</td>
</tr>
<tr>
<td>pH &lt; 7.00 (%)</td>
<td>2.7</td>
<td>2.7</td>
<td>NS</td>
</tr>
<tr>
<td>Low Apgar at 5 min (%)</td>
<td>1.1</td>
<td>0.6</td>
<td>NS</td>
</tr>
<tr>
<td>NICU admission (%)</td>
<td>16.4</td>
<td>11.5</td>
<td>NS</td>
</tr>
</tbody>
</table>

SEM, standard error of the mean; NICU, neonatal intensive care unit; NS, not significant.

comparison to the control group, neonatal outcome measurements did not differ in the group induced for oligohydramnios (Table 1)86. Significantly higher Cesarean delivery rates were observed among women whose labor was induced vs. controls (15.8% vs. 6.6%, respectively). The increased need for operative delivery was not attributable to an increase in fetal distress in the oligohydramnios group. The authors concluded that isolated oligohydramnios in the otherwise normal term pregnancy may not be a marker for fetal compromise and that induction of labor may therefore not be warranted in most cases86. It should however be emphasized that in this study the safety of embarking upon a non-interventional, expectant management of cases with isolated oligohydramnios at term was not evaluated. In an additional analysis, infants were subsequently stratified according to amniotic fluid index (oligohydramnios (AFI < 5.0) vs. normal (AFI ≥ 5.0)) and ponderal index (low vs. normal), in an attempt to identify whether neonates with evidence of compromised intrauterine nutrition and oligohydramnios were at particularly high risk for adverse outcome. Interestingly, no significant differences were noted between the four groups.

In the only study in which women (n = 61) with isolated oligohydramnios diagnosed by AFI values ≤ 5 cm were randomly allocated to expectant management vs. induction of labor, Conway et al.86 reported that the majority of patients managed expectantly entered spontaneous labor within 3 days of sonographic diagnosis. Interestingly, this observation indirectly supports the previously mentioned consideration that the physiology of decreasing amniotic fluid volume at term or thereafter may represent a normal component of the mechanism of spontaneous labor. Patients in the expectant management group underwent twice-weekly fetal testing. Maternal hydration was not utilized prior to enrolment and intrapartum amnioinfusion was not used. None of the patients in the expectantly managed group was induced due to fetal compromise and the authors concluded that expectant management of patients with isolated oligohydramnios was appropriate86.

CONCLUSION

Recent evidence is accumulating that suggests that in the presence of an appropriate-for-gestational age fetus, with reassuring fetal well-being (including Doppler velocimetry of the umbilical artery) and the absence of maternal disease, oligohydramnios is not associated with an increased incidence of adverse perinatal outcome. Accordingly, given the poor current sonographic capability to correctly diagnose decreased amniotic fluid volume (other than overt oligohydramnios), the reported transient nature of oligohydramnios, and evidence that amniotic fluid volume may be increased with maternal hydration, it appears that induction of labor (or delivery) at term for decreased amniotic fluid volumes should be reconsidered. In summary, in our view, four challenging questions remain unanswered at this time.

1. In an attempt to decrease the overdiagnosis of isolated oligohydramnios, should strict uniform maternal hydration status criteria be implemented prior to ultrasound assessment of amniotic fluid volume? This would clearly assist in avoiding inadvertent inclusion of relatively dehydrated women in whom oligohydramnios may reflect a transient and correctable finding.

2. Should patients with isolated oligohydramnios at term continue to undergo induction of labor? Clearly the time has arrived for seeking prospective randomized data regarding the value of delivery indicated solely on the basis of decreased amniotic fluid volume in the absence of any other objective concerns.

3. Should other (less invasive) management paradigms of the patient at term with isolated oligohydramnios including increase in maternal volume intake (either oral or intravenous) and subsequent reassessment of amniotic fluid volume be entertained?

4. Finally, what is the significance of a full (or distended) fetal bladder noted in conjunction with isolated oligohydramnios? Alternatively, should any bladder measurement be considered when diagnosing oligohydramnios?

REFERENCES

2 Gilbert WM, Brace RA. Amniotic fluid volume and normal flows to and from the amniotic cavity. Semin Perinatol 1993; 17: 150–7
7 Magaan EF, Bass JD, Chauhan SP, Young RA, Whitworth NS, Morrison JC. Amniotic fluid volume in normal singleton pregnancies. Obstet Gynecol 1997; 90: 524–8
8 Wintour EM, Shandley L. Effects of fetal fluid balance on amniotic fluid volume. Semin Perinatol 1993; 17: 158–72
of marginal and decreased amniotic fluid volumes to perinatal outcome. *Am J Obstet Gynecol* 1984; 150: 245–9
24 Flack NJ, Sepulveda B, Bower S, Fisk NM. Acute maternal hydra-
36 Babcock CJ, Silmera M, Drake C, Levine D. Effect of maternal hydra-
41 Chauhan SP, Maaga EF, Cowan BD, Perry KG, Morrison JC. Mathematical model to correlate amniotic fluid index and amniotic fluid. *J Miss State Med Ass* 1998; 39: 6–9
44 Sherer DM, Mann SE, Sardo MP, Divon MY. Transvaginal sonogra-
45 Rutherford SE, Smith CV, Phelan JP, Kawakami K, Ahn MO. Four-
46 Rutherford SE, Smith CV, Phelan JP, Kawakami K, Ahn MO. Four-
51 Brown DL, Polger M, Clark PK, Bromley BS, Doubllet PM. Very echogenic amniotic fluid: ultrasonography-amniocentesis correla-
56 Halperin ME, Fong KW, Zalev AH, Goldsmith CH. Reliability of amniotic fluid volume estimation from ultrasonograms: intraobserver and interobserver variation before and after the establish-
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74 Wing DA, Fishman A, Gonzalez C, Paul RH. How frequently should the amniotic fluid index be performed during the course of antepartum testing? *Am J Obstet Gynecol* 1996; 174: 33–6


