Assessment of amniotic fluid volume

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INTRODUCTION — Normal amniotic fluid volume (AFV) varies across gestation (figure 1). The sonographic assessment of AFV will be discussed here. Factors that influence AFV and specific disorders of AFV (oligohydramnios and polyhydramnios) are reviewed separately:

- (See "Physiology of amniotic fluid volume regulation".)
- (See "Oligohydramnios".)
- (See "Polyhydramnios".)

WHEN TO ASSESS AFV — Qualitative or semi-quantitative assessment of AFV is a standard component of every second- and third-trimester ultrasound examination [1,2].

CLINICAL SIGNIFICANCE OF ABNORMAL AFV

- Reduced or absent amniotic fluid can be caused by premature rupture of membranes.
- Abnormal AFV may suggest fetal congenital anomalies (eg, gastrointestinal or urinary tract obstruction, renal abnormality), chromosomal abnormalities (eg, trisomy 18), and fetal growth restriction.
- Abnormal AFV has been associated with an increased risk of a variety of adverse perinatal outcomes [3-5].

For these reasons, identification of abnormal AFV should prompt evaluation for premature rupture of membranes, fetal abnormalities, and pregnancy complications related to utero-placental insufficiency.

In clinical practice, ultrasound estimation of AFV is used in conjunction with other clinical and sonographic assessments (eg, biophysical profile, nonstress test, ultrasound examination for estimated fetal weight, anatomic survey) to provide information for assessing fetal well-being and managing complicated pregnancies.

DYE DILUTION AND COLLECTION OF AMNIOTIC FLUID: THE REFERENCE STANDARDS — Dye dilution and collection of amniotic fluid at hysterotomy are the reference standards for assessment of AFV. Use of these techniques is generally restricted to research studies where they represent the reference for evaluating the accuracy of ultrasound measurements of AFV.

Dye dilution is an accurate method for antenatal determination of total AFV [6]. However, this technique is invasive, cumbersome, and requires specialized technical skills and laboratory support.

Collection and measurement of amniotic fluid at the time of cesarean delivery or pregnancy termination is another accurate method for assessing AFV, and its accuracy is similar to the dye dilution techniques [7]. However, this is not an option for ongoing fetal assessment during pregnancy, and blood can contaminate the specimen.

ULTRASOUND ESTIMATION OF AFV — Ultrasound examination is the only practical clinical method of assessing AFV. The following five ultrasound methods are used clinically; each has limitations in the detection of abnormal AFVs.

Qualitative assessment — Qualitative assessment of AFV refers to subjective interpretation without sonographic measurements [8]. The ultrasonographer scans the uterine contents and subsequently reports the AFV as oligohydramnios, normal, or polyhydramnios based on his/her clinical expertise.

One study involving 63 pregnancies compared the qualitative assessment of AFV with semi-quantitative methods (amniotic fluid index, single deepest pocket, and two-diameter pocket) and used dye-determined AFV as the standard [8]. Qualitative assessment of AFV by an experienced examiner had similar sensitivity as the semi-quantitative techniques. Both qualitative and semi-quantitative ultrasound methods identified normal volumes well, but concordance with low and high AFV by dye dilution was poor [8].

Semi-quantitative methods

Single deepest pocket — The single deepest pocket (SDP) (also called the maximum vertical pocket [MVP] or the largest vertical pocket) is the vertical dimension in centimeters of the largest pocket of amniotic fluid not persistently containing umbilical cord or fetal extremities (on gray-scale examination) and measured at a right angle to the uterine contour. The horizontal component of the vertical dimension must be at least 1 cm.

For diagnosis of oligohydramnios in patients with a persistent single loop of cord in this pocket, it is most accurate to measure the largest vertical distance to the cord, either above or below but not through the cord [9].

A 2014 consensus panel at a fetal imaging workshop suggested the following interpretation of SDP [10]:

- Oligohydramnios – Depth <2 cm
- Normal – Depth ≥2 cm and <8 cm
- Polyhydramnios – Depth ≥8 cm

These thresholds are generally accepted, although slight variations are common (eg, <2 versus ≤2 to define oligohydramnios) [11].

The SDP technique detects fewer pregnancies with low AFV than dye dilution and direct assessment methods. In a study of 40 pregnancies that compared the SDP with dye-determined AFV, 94 percent of normal pregnancies were identified by SDP, but none of the pregnancies with a low dye-determined AFV were detected (low dye dilution AFV was defined as ≤5th percentile) [12]. In another study of 45 pregnancies that compared SDP with direct measurement of AFV at cesarean delivery, SDP identified only 18 percent of the pregnancies with low AFV by collection of amniotic fluid [13].

Amniotic fluid index — The amniotic fluid index (AFI) is calculated by dividing the uterus into four quadrants using the linea nigra for the right and left divisions and the umbilicus for the upper and lower quadrants. The maximal vertical amniotic fluid pocket diameter in each quadrant not containing cord or fetal extremities (on gray-scale examination) is measured in centimeters; the sum of these measurements is the AFI. A 2014 consensus panel at a fetal imaging workshop suggested the following interpretation of AFI [10]:

- Oligohydramnios – AFI ≤5 cm
- Normal – AFI >5 cm and <24 cm
- Polyhydramnios – AFI ≥24 cm

These thresholds are generally accepted, although slight variations are common. For example, polyhydramnios has been defined as AFI >18, >20, >24, and >25 cm [14-16].

An AFI of 5.1 to 8 cm has been termed borderline, but the clinical implications are unclear, and there is no strong evidence to support additional antenatal assessment of these pregnancies [17]. We manage pregnancies with an AFI of 5.1 to 8 cm the same way as an AFI above 8 cm, without additional testing or hydration. However, it is also reasonable for the clinician to elect closer follow-up (eg, twice weekly) of patients with AFI values near the level of oligohydramnios.

The accuracy and prognostic value of the AFI has been examined in several studies, which have shown that an abnormal test (low or high) is neither highly accurate nor predictive of adverse outcome [3,6,12,18-20]. Many pregnancies with normal AFV will be falsely characterized as abnormal, and a large number with truly abnormal AFVs will be missed. Use of percentiles rather than fixed cutoffs to identify low or high AFVs does not improve the accuracy of the method.

These findings are illustrated by the following representative examples:

- In three studies that compared AFI with dye dilution, AFI was concordant with dye dilution in 71, 78, and 87 percent of pregnancies with normal AFV by the reference standard [6,12,18]. AFI was less accurate with abnormal AFVs:
  - In one of these studies, at low AFV, the AFI overestimated dye-determined volumes by 89 percent, while at high AFV, the AFI underestimated dye-determined volumes by 54 percent [6].
  - In the other two studies, AFI identified only approximately 10 percent of pregnancies with low AFV by dye dilution [12,18].
- In another analysis of these two techniques in 144 pregnancies, receiver operator characteristic curves were used to calculate the upper limit of AFI at which oligohydramnios could be excluded with 95 percent confidence [19]. The authors concluded this value was 30 cm, a value typically considered to represent polyhydramnios. The sensitivity, specificity, positive predictive value, and negative predictive value of AFI ≤5 for oligohydramnios were 5, 98, 80, and 49 percent; these same characteristics for AFI >24 for polyhydramnios were 30, 98, 57, and 93 percent.
- Lastly, dye-determined AFV was used to evaluate 291 singleton pregnancies with AFI and SDP <3rd and 5th percentiles and >95th and 97th percentiles, adjusted for gestational age [20]. The sensitivity of AFI or SDP <3rd and 5th percentiles to detect oligohydramnios ranged from 11 to 27 percent and was 33 to 46 percent for detection of hydramnios. Use of

percentiles was no better than fixed cutoffs (eg, AFI ≤5 or >25, SDP <2 or >8 cm) for detecting oligohydramnios and polyhydramnios.

Two-diameter pocket technique — The two-diameter amniotic fluid pocket is rarely used and not recommended. It is the product of the vertical depth in centimeters multiplied by the horizontal diameter in centimeters of the largest pocket of amniotic fluid not containing umbilical cord or extremities (on gray-scale examination), with the transducer held at a right angle to the uterine contour. Results are interpreted as follows [12]:

- Oligohydramnios – 0 to 15 cm^2
- Normal – 15.1 to 50 cm^2
- Polyhydramnios – Greater than 50 cm^2

Two series that compared the two-diameter pocket and dye-determined AFV found the former identified 81 to 94 percent of the dye-determined normal AFVs and approximately 60 percent of pregnancies with low volumes [12,18]. Receiver operator curve analysis showed that, for any specific two-diameter pocket, the 95 percent confidence range was so wide that ultrasonographic assessment was not a reasonable reflection of actual AFV and thus was not clinically useful [19].

2 by 1 cm or 2 by 2 cm pocket technique — These methods of amniotic fluid assessment involve identification of at least one pocket of amniotic fluid with minimum dimensions of 2 by 1 cm or 2 by 2 cm measured vertically and horizontally (or horizontally and vertically) not containing umbilical cord or fetal extremities (on gray-scale examination). The 2 by 1 cm pocket technique is one of the five components of the biophysical profile [21]. (See "The fetal biophysical profile".)

The 2 by 2 cm pocket is a subsequent innovation; its ability to predict an adverse intrapartum or perinatal outcome is uncertain [21]. When the 2 by 2 cm pocket technique was compared with a dye-determined AFV in 79 pregnancies, the pocket technique identified 98 percent of pregnancies with normal dye-determined volume but only 9.5 percent of those with low volumes [22].

Use of concurrent color Doppler — The concurrent use of color Doppler has been proposed to identify umbilical cord in an amniotic fluid pocket that is not seen by gray-scale ultrasonography alone, since pockets of amniotic fluid containing umbilical cord should not be used for measurement of AFV.

There is no consensus for or against use of color Doppler when assessing AFV. We caution against using color Doppler as a component of AFV assessment because its use results in over diagnosis of oligohydramnios [23-25], which may lead to more pregnancy interventions without an improvement in perinatal outcomes, and possible harm from the interventions. As an example, a study of AFV assessment with and without concurrent color Doppler found that both AFI and SDP measurements were approximately 20 percent lower when color Doppler was used [25]. Importantly, the authors also measured AFV by dye dilution techniques and found that using color Doppler did not improve the diagnostic accuracy of oligohydramnios and misclassified nine of 42 pregnancies with normal amniotic fluid as having oligohydramnios. Furthermore, the standards for assessment of AFV described above were established without use of color Doppler.

Our approach — We perform a qualitative assessment of AFV in all ultrasound examinations. In addition, we use a semi-quantitative measure (eg, SDP or AFI) if the qualitative assessment is abnormal, in patients at increased risk of pregnancy complications, and in all patients examined in the third trimester.

We prefer the SDP technique. It is one of the components of the biophysical profile and has been validated as useful for the evaluation of pregnancies at risk for an adverse pregnancy outcome [26,27] (see "The fetal biophysical profile"). We prefer the SDP to the AFI because a 2008 systematic review of randomized trials found that use of the AFI increased the rate of diagnosis of oligohydramnios (relative risk [RR] 2.3), induction of labor (RR 2.1), and cesarean delivery for fetal distress (RR 1.5) without improving peripartum outcomes [28]. Subsequent trials have affirmed this finding [29].

There is limited information on the management of an SDP between 2 and 3 cm. We label an SDP ≥2 cm as normal and manage the pregnancy as we would a pregnancy with normal AFV. However, as with borderline normal AFI values, the clinician may elect closer follow-up (eg, twice-weekly assessments) of patients with SDP values near the level of oligohydramnios or with SDP values derived from a single visible pocket (in which case a simultaneously performed AFI may be ≤5 cm).

We believe the most clinically relevant sonographic method for AFV assessment is the one that best identifies pregnancies at risk for an adverse outcome rather than the one that best correlates with volume by dye dilution or volume outside of a 95 percent confidence interval for gestational age. We also appreciate that in all but postterm pregnancies, all sonographic methods of assessing AFV poorly predict adverse pregnancy outcome.

SPECIAL POPULATIONS

Gestational age 14 to 20 weeks — Modifications are necessary for pregnancies less than 20 weeks of gestation. There is limited information on the earliest gestational age that ultrasound measurements can be used to estimate AFV. One problem for measurement of amniotic fluid index (AFI) is that only two quadrants exist before 20 weeks because the fundus may be below the umbilicus. In one study of AFI in pregnancies from 16 to 44 weeks, this problem was addressed by dividing the uterus into four quadrants created by an imaginary vertical line along the maternal midline and another imaginary transverse line midway between the top of the uterine fundus and the symphysis pubis [30]. In another study of AFV in pregnancies from 14 to 41 weeks, AFV was estimated using the AFI, single deepest pocket (SDP), and two-diameter pocket techniques, but the AFI was calculated from the sum of the SDP of only two quadrants in those pregnancies in which the uterine size was below the umbilicus [31].

We suggest using the SDP technique to estimate AFV in pregnancies between 14 and 20 weeks. AFI reference ranges (table 1), SDP reference ranges (table 2), and two-dimensional pocket reference ranges (table 3) exist for normal pregnancies from 14 weeks [30,31]. However, the normal AFV at any point in gestation sometimes differs depending on the population being investigated; thus, the percentiles in these tables may not apply to patients in other medical settings. The correlation of these methods to dye-determined AFV in early pregnancies is uncertain. The only study that correlated ultrasound measurements with dye-determined AFV in 42 singleton pregnancies between 15 and 23 weeks found that the SDP correctly identified 3/8 with dye-determined oligohydramnios and 26/29 with normal dye-determined AFV compared with 2/8 with oligohydramnios and 22/29 with normal fluid volume using the AFI [32].

Multifetal pregnancy — We suggest qualitative assessment in multifetal pregnancies. If a semi-quantitative measurement is needed, we measure the SDP of each amniotic sac.

In twin pregnancies, the assessment of AFV is an important part of their overall evaluation since they have a perinatal mortality rate severalfold higher than singleton pregnancies. As with singleton pregnancies, normal AFV in diamniotic twin pregnancies has been determined by studies using dye dilution techniques [33]. These studies have noted that (1) the mean AFV in each sac of a twin pregnancy is slightly higher than that of a singleton pregnancy of the same gestational age, and (2) qualitative and semi-quantitative sonographic techniques tend to underestimate abnormalities of AFV compared with dye dilution techniques [34].

Three ultrasound techniques have been used to estimate the AFV in diamniotic twin pregnancies. All three methods correlate poorly with dye-determined low or high volumes, in part because the position of the dividing membrane affects the interpretation if each twin is evaluated separately. Our approach was described above; the limited available evidence is reviewed below.

- **Qualitative assessment** – A study including 23 twin pregnancies subjectively and objectively evaluated AFV and then compared these results with the dye-determined volume [35]. There were no differences in the accuracy of the subjective versus the objective evaluation of AFV to identify abnormal volumes, and both techniques were equally poor in the identification of the extremes (high and low) of AFV.

- **SDP** – The SDP of each sac is measured and the results interpreted using the SDP criteria described above for singletons [34] (see 'Single deepest pocket' above). This is possible because the 2.5th and 97.5th percentiles for twins are 2.3 cm and 7.6 cm, respectively, which are similar to the singleton cutoffs of 2 cm and 8 cm to define oligohydramnios and polyhydramnios [10]. Using this technique, high SDPs have been correlated with abnormal fetal heart rate tracings in labor and an increased frequency of cesarean deliveries for fetal intolerance of labor [36].

- **AFI** – AFI in twins can be performed the same way as in singleton pregnancies (see 'Amniotic fluid index' above). Without taking the membrane separating the twins into consideration (if diamniotic) [37,38], the deepest vertical pocket without fetal small parts or cord (on gray-scale examination) is determined in each quadrant, and the sum of the measurements of the four quadrants is calculated. The AFI is interpreted using standard criteria used in singleton pregnancies as the 5th and 95th percentiles of AFI for twins approximates those of singletons [30,37]. Thus, in twin pregnancies, an AFI ≤5 cm suggests oligohydramnios, AFI >5 and <24 cm suggests a normal volume, and AFI ≥24 cm suggests polyhydramnios. Other AFI techniques have also been used to estimate AFV in twins, such as locating the dividing membrane and measuring the AFI in four quadrants of each sac [39].

  The AFI in twin pregnancies has poor intra- and interobserver agreement. The method in which membrane placement is not considered overidentifies abnormal AFVs as normal. In addition, the summated AFI is a poor predictor of inter-twin differences in AFV and does not perform well for identifying twin pairs at risk for oligohydramnios and polyhydramnios. In a study of 62 diamniotic twin pregnancies in which the AFV was determined by both dye dilution and AFI, the summated AFI identified 94 percent of the twin pairs (58/62) as having normal total fluid volumes; however, only 52 percent (32/62) were normal by dye dilution [40]. Summated AFI failed to correctly classify 8 of 10 sets of twins with low fluid volume in both sacs on dye dilution as well as 4 of 5 patients with high fluid in one sac and normal fluid in the other sac on dye dilution. The remaining misclassifications were in twin sets with high/low (4/4 misclassified as normal) or normal/low (10/11 misclassified as normal) fluid on dye dilution.

SUMMARY AND RECOMMENDATIONS

- Qualitative or semi-quantitative assessment of amniotic fluid volume (AFV) is a standard component of every second- and third-trimester ultrasound examination. (See 'When to assess AFV' above.)

- Abnormalities of AFV are associated with a variety of pregnancy complications. In clinical practice, ultrasound estimation of AFV is used in conjunction with other clinical and sonographic assessments (eg, biophysical profile, nonstress test, ultrasound examination for estimated fetal weight, anatomic survey) to provide information for assessing fetal well-being and managing complicated pregnancies. (See 'Clinical significance of abnormal AFV' above.)

- The most common ultrasound techniques used to estimate the adequacy of AFV are the single deepest pocket (SDP), amniotic fluid index (AFI), and qualitative assessment. (See 'Ultrasound estimation of AFV' above.)
- Qualitative and semi-quantitative ultrasound methods perform well in identifying pregnancies with normal AFVs but are less accurate for diagnosis of oligohydramnios and polyhydramnios. (See 'Qualitative assessment' above.)
- We perform a qualitative assessment of AFV in all ultrasound examinations. We obtain an SDP measurement if the qualitative assessment is abnormal, in patients at increased risk of pregnancy complications, and in all patients examined in the third trimester. (See 'Our approach' above.)
- The SDP and the AFI methods are equivalent in their prediction of adverse outcomes and actual oligohydramnios and polyhydramnios in singleton pregnancies, but use of the AFI increases the number of labor inductions and cesarean deliveries without any improvement in perinatal outcome. This favors use of the SDP for AFV assessment. (See 'Amniotic fluid index' above.)
- Ultrasound estimates of AFV in multifetal pregnancies correlate poorly with dye-determined low or high volumes. We suggest qualitative assessment in multifetal pregnancies and use of the SDP for each amniotic sac if a semi-quantitative measurement is needed. The results for each fetus are interpreted using the same SDP criteria used for singletons. (See 'Multifetal pregnancy' above.)

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GRAPHICS

Mean amniotic fluid volume across normal pregnancy

These values represent the 50th percentile. There is considerable variability around the mean. The 5th, 50th, and 95th percentiles at 33 weeks of gestation are approximately 300, 800, and 1900 mL, respectively.

Data from: Brace RA, Wolf EJ. Normal amniotic fluid volume changes throughout pregnancy. Am J Obstet Gynecol 1989; 161:382.

Graphic 59704 Version 6.0

Amniotic fluid index (AFI) from 14 to 20 weeks of gestation

Weeks of gestation	5th percentile	10th percentile	50th percentile	90th percentile	95th percentile
14	2.8	3.1	5.0	8.0	8.6
15	3.2	3.6	5.4	8.2	9.1
16	3.6	4.1	5.8	8.5	9.6
17	4.1	4.0	6.3	9.0	10.3
18	4.6	5.1	6.8	9.7	11.1
19	5.1	5.6	7.4	10.4	12.0
20	5.5	6.1	8.0	11.3	12.9

These values are based on findings in singleton pregnancies with reliable gestational age assessment, no known fetal anomalies, and no medical or obstetric complications. At each gestational age, 50 patients were recruited, and only one examination was used per pregnancy.

Data from: Magann EF, Sanderson M, Martin JN, Chauhan S. The amniotic fluid index, single deepest pocket, and two-diameter pocket in normal human pregnancy. Am J Obstet Gynecol 2000; 182:1581.

Graphic 107646 Version 2.0

Single deepest pocket (SDP) at 14 to 20 weeks of gestation

Weeks of gestation	5th percentile	10th percentile	50th percentile	90th percentile	95th percentile
14	1.7	1.9	2.9	4.7	5.0
15	2.0	2.2	3.4	5.1	5.5
16	2.3	2.5	3.6	5.4	5.9
17	2.5	2.7	3.9	5.7	6.2
18	2.7	2.9	4.1	5.9	6.4
19	2.8	3.1	4.3	6.1	6.6
20	2.9	3.2	4.4	6.2	6.7

These values are based on findings in singleton pregnancies with reliable gestational age assessment, no known fetal anomalies, and no medical or obstetric complications. At each gestational age, 50 patients were recruited, and only one examination was used per pregnancy.

Data from: Magann EF, Sanderson M, Martin JN, Chauhan S. The amniotic fluid index, single deepest pocket, and two-diameter pocket in normal human pregnancy. Am J Obstet Gynecol 2000; 182:1581.

Graphic 107647 Version 2.0

Two-dimensional pocket at 14 to 20 weeks of gestation

Weeks of gestation	5th percentile	10th percentile	50th percentile	90th percentile	95th percentile
14	4.3	4.7	9.5	18.3	22.6
15	5.8	6.4	13.0	23.8	28.3
16	7.3	8.1	16.6	29.2	33.7
17	8.7	9.6	19.8	33.8	38.5
18	9.8	10.9	22.5	37.6	42.4
19	10.6	11.9	24.3	40.3	45.3
20	11.0	12.6	25.4	42.0	47.4

These values are based on findings in singleton pregnancies with reliable gestational age assessment, no known fetal anomalies, and no medical or obstetric complications. At each gestational age, 50 patients were recruited, and only one examination was used per pregnancy.

Data from: Magann EF, Sanderson M, Martin JN, Chauhan S. The amniotic fluid index, single deepest pocket, and two-diameter pocket in normal human pregnancy. Am J Obstet Gynecol 2000; 182:1581.

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