Ultrasound Prediction of Amniotic Fluid Volume

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Using ultrasonography, we measured the largest vertical dimension for pockets of amniotic fluid (largest vertical pocket) directly before elective cesarean delivery in 42 pregnant women and compared the results to actual amniotic fluid volume (AFV). In another 3 pregnant women of vaginal delivery suspected polyhydramnios, we performed amniocentesis and successively recorded the largest vertical pocket and actual AFV, and finally made a fitting curve and correlative equation. A high degree of correlation was found between the largest vertical pocket measured by ultrasound and the actual AFV. The equation is: $Y=63.03-8.46X+0.71X^2-0.01X^3+0.00006X^4$. Using the equation obtained which relates largest vertical pocket to actual AFV; a 30mm largest vertical pocket corresponds to an actual volume of 200ml, an 80mm largest vertical pocket to 800ml, and a 120mm largest vertical pocket to 3,000ml. In conclusion, the largest vertical pocket is well reflected in the actual AFV.

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1. INTRODUCTION

Information about amniotic fluid volume (AFV) is very useful in determining the fetal condition.[1,2] However, accurate antepartum estimation of AFV by clinical means alone, is exceedingly difficult. Prenatal estimation of AFV was tried by a dye-dilution technique.[3-6] But this method is not always clinically available, and it is difficult for patients to apply for screening method.

Manning and colleagues[1] reported a qualitative method for the estimation of AFV by ultrasound. They have reported an increased incidence of fetal growth restriction (FGR) and an increased perinatal mortality in infants in whom the largest vertical pocket of amniotic fluid is decreased. Although, several investigators[7-15] have reported that these criteria may be useful as a screening tool for fetal condition, the quantitative relation between the qualitative AFV indicator and the actual volume of amniotic fluid has not yet been fully defined. Our object in this report was to investigate the correlation between the largest vertical pocket and actual volume of amniotic fluid.

2. MATERIALS AND METHODS

All patients studied were scanned in the supine position using a real-time ultrasound method (ALOKA SSD2000). Fetal number, fetal biometric parameters, fetal viability, and placental location were confirmed ultrasonographically.[2] The entire uterus was scanned to determine the fetal lie and attitude. Pockets of amniotic fluid were identified, and the vertical diameters of the pockets were determined in freeze-frame mode with electronic calipers. In most instances, the largest vertical pockets of amniotic fluid were found about the limbs and close to the fetal neck. This method is almost the same as that described by Manning et al.[1]

1) The measurement of the largest vertical pocket and the actual AFV

The study group included a total of 45 Japanese women

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with singleton pregnancies between 35 and 41 weeks of gestation. Informed consent for participation in the study was obtained from all patients. For 42 cases of delivery by elective cesarean section, the relationship between the largest vertical pocket as measured by ultrasound directly before delivery and the actual AFV was determined. Actual AFV was measured at the time of cesarean section. The uterus was opened through the lower uterine segment transversely with an approximately 1 cm incision. A suction catheter was inserted carefully through the lower uterine segment incision. Then in each of these 42 cases an attempt was made to aspirate as much amniotic fluid as possible. After that, we extended the incision and we pushed up the presentation part of the fetus and aspirated the remaining amniotic fluid from the lower space of the uterine cavity. In three cases with polyhydramnios of vaginal delivery, 18 serial measurements were taken at every point of removal of amniotic fluid from 200 to 1,000ml by transabdominal amniocentesis. We measured actual AFV remaining in the uterine cavity at delivery. Finally, AFV at each point at which the largest vertical pocket was measured was determined by adding removed AFV to AFV remaining in the uterine cavity at delivery. A total of 60 recordings were obtained for the 45 cases.

2) Statistical analysis

All above results were represented in scattergram, and the correlation between the largest vertical pocket and actual AFV was described in a polynomial equation by regression analysis.

3. RESULTS

1) The measurement of the largest vertical pocket and the actual AFV

In 42 cases of delivery by elective cesarean section, the largest vertical pocket directly before delivery ranged from 5 to 110mm, and the actual AFV ranged from 10 to 2,000ml. In 3 cases of vaginal delivery, total AFVs were 4,876ml, 1,825ml and 1,500ml, respectively. Correlation between the largest vertical pocket and the retrospectively calculated AFV was as follows: in case 1, 133mm: 4,876ml, 124mm: 3,876ml, 112mm: 2,876ml, 104mm: 1,876ml, 85mm: 1,376ml, 76mm: 1,076ml, 68mm: 876ml. In case 2, 108mm: 1,825ml, 67mm: 825ml. In case 3, 110mm: 1,500ml, 100mm: 1,400ml, 97mm: 1,300ml, 95mm: 1,100ml, 90mm: 900ml, 86mm: 800ml, 80mm: 700ml, 75 mm: 600ml, 73mm: 570ml.

2) Statistical analysis

We made a scattergram from the results of 42-cross-sectional studies and 18 serial studies (Figure 1). The X-axis refers to the largest vertical pocket and the Y-axis is the actual AFV. Good correlation was found between these parameters, with the polynomial equation being: $Y=63.03-8.46X+0.71X^2-0.01X^3+0.00006X^4$ (multiple regression coefficient=0.9782). However, because this equation has an inflection point at X=7, the Y value increases as the X value decreases from 7(at the point of X=7, Y=35.31 that is the minimal Y value by this equation). We consider that this equation does not fit when the largest vertical pocket is less than 7mm. In one of our cases the largest vertical pocket was 5mm and the actual amniotic fluid was 10ml. At this point, the error of estimation of volume by our equation is 280% and this value is excessively higher than for other cases (Fig.2).

Table 1 shows the estimation of AFV from the largest vertical pocket of amniotic fluid by our equation (Table 1).

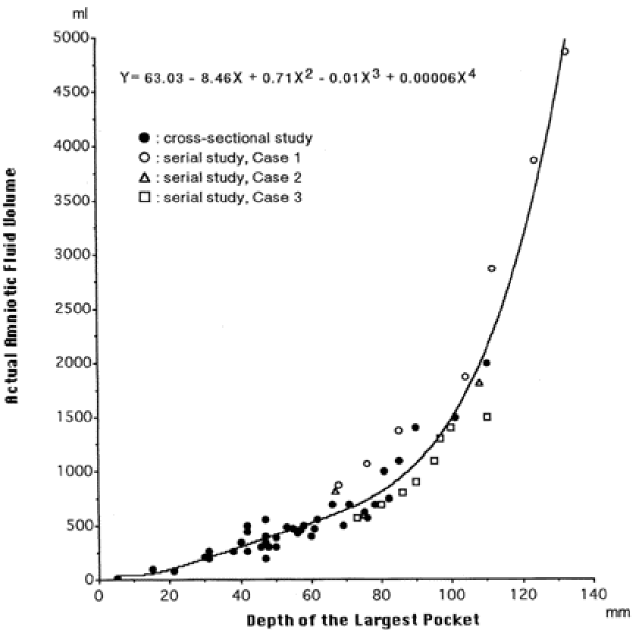

Figure 1. The correlation between the depth of the largest pocket of amniotic fluid and actual amniotic fluid volume.

4. DISCUSSION

Ultrasonographies enabled accurate delineation of normal and abnormal fetal anatomy. Ultrasonographic imaging appears to have no harmful effect on the mother or on the fetus. The ability of prenatal ultrasonography to diagnose

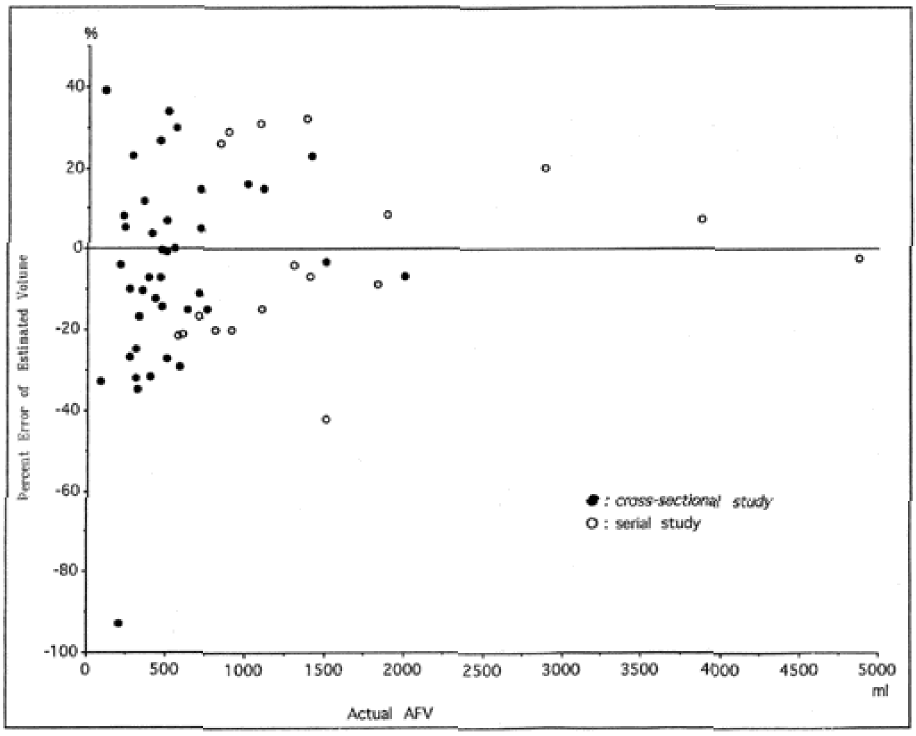

Figure 2. Actual AFV is given on the X axis. The percent error associated with volume estimation based on the depth of the largest pocket is given on the Y axis. This figure excluded one case with a depth of the largest pocket of less than 7mm as the error was 280%.

Table 1. Estimation of amniotic volume from the depth of largest pocket

depth of largest pocket	10	20	30	40	50	60	70	80	90	100	110	120	130
estimated volume	40	100	200	310	420	530	650	820	1,100	1,500	2,100	3,100	4,500

fetal abnormalities, both as a screening tool and for targeted examinations, has also been confirmed.[2]

Although amniotic fluid is very important for the environment surrounding the fetus, it is difficult to determine with precision the AFV during pregnancy. Prenatal determination of AFV has been attempted using a dye-dilution technique.[3-6] The relationship between the largest vertical pocket or amniotic fluid index and actual AFV has been examined by the dye-dilution methods[3, 4], which is, however, rarely available clinically and difficult to use for purpose of screening test. Screening tests are performed on all pregnant women in order to identify a subset of patients who are at high-risk of the disorder. They do not confer any risk to the pregnancy and are performed for disorders with a relatively high prevalence and for which there are accurate prenatal diagnostic tests. Screening tests include not only maternal biochemistry and maternal virology but also ultrasound examination.

In this study, we measured both the largest vertical pocket and the actual AFV on the day of delivery, and found a high degree of correlation between them. Using our graph, AFV can be estimated from the largest vertical pocket by ultrasound. We previously investigated the largest vertical pocket in infants who were appropriate for gestational age[8], and its average during third trimester is 50-60mm, with normal range from 30mm to 80mm(±2SD). In our another study[9], incidences of fetal distress was significantly higher in the group of patients with FGR who also had decreased amniotic fluid (10〜30mm largest vertical pocket) than a group with normal fluid (30〜80mm), or a group with increased fluid (80〜110mm), respectively. By our correlative equation, a 30mm depth of the largest pocket is equivalent to 200ml of AFV and 80mm is equivalent to 800ml.

Manning et al1.[1] measured the largest vertical pocket using ultrasound in order to estimate qualitatively the AFV. In their study, of 29 patients in which the largest vertical pocket was less than 10mm, 26 patients were delivered of a fetus with FGR. Thereafter, Hoddick et al.[10], Hill et al.[11], and Chamberlain et al.[12] have each reported that the 10mm criterion may be too rigid for use as a screening tool, since the incidence of largest vertical pocket less than 10mm is quite low in the normal obstetric population. The largest vertical pockets of 5mm[13], 10mm[1], 20mm[12], and 30mm[14] have each been reported to be the lower limit of normal AFV. And those groups with measurements beneath these lower limits had an abnormally high incidence of FGR and fetal anomalies. We previously demonstrated[9] that the incidence of FGR was significantly increased among patients whose largest vertical pocket was less than 30mm (57.7%). In addition, the combination of clinical suspicion of FGR and documented decrease in amniotic fluid (less than 30mm) may indicate that the probability of development of fetal distress is high (71.0%). We believe that measurement of the largest vertical pocket should be used not only for screening for FGR but also for estimation of the risk of fetal distress.

It has been reported that largest vertical pocket more than 80mm can be considered the upper limit of normal amniotic fluid volume[15]. The increased fluid group (more than 80mm) had an abnormally high incidence of fetal macrosomia and fetal anomalies.

In this study, the data of cases with low amniotic volumes are insufficient and further examination will be required especially in cases with less than 35ml AFV. However, this study includes data from serial studies and data from cross-sectional studies fitted our curve as well as these serial-sectional data. Our equation is available to estimate AFV in a simple method, and therefore it can be clinically applied.

Ultrasound imaging is an integral part of obstetric practice today. It is used routinely for accurate dating of pregnancy, confirmation of pregnancy location and number of gestations, prenatal diagnosis of congenital malformations, and assessment of AFV. Three-dimensional ultrasonography is now also available for intrauterine imaging and has the potential to revolutionize the field of prenatal imaging including AFV assessment.

In conclusion, ultrasound amniotic fluid volumetry is an easy and reliable method for the estimation of actual AFV and determination of fetal condition.

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