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ORIGINAL ARTICLE

Assess the Accuracy and Reliability of Advanced Ultrasound Techniques in Predicting and Managing Abnormal AFI and Mitigating Potential Fetal Outcome

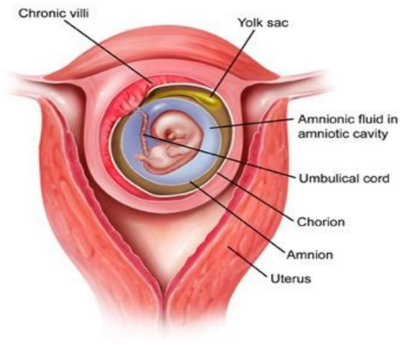
AHTASHAM AMJAD[1], MADIHA IQBAL[2], KHAWAJA RUMAN AHMAD[3]
[1]*Department of Radiology at Afro Asian institute.*
[2]*Community Medicine, Biostatistician at Punjab Institute of Cardiology and Senior Lecturer at Shalamar Hospital, Lahore*
[3]*Lecturer RIT Focal Person Punjab Medical and Punjab Pharmacy Council.*
Correspondence to Dr. Ahtasham Amjad, Email Ahtashamamjad2@gmail.com, Phone: 03214122601

ABSTRACT

Background: This research seeks to provide a comprehensive and standardized approach to AFI assessment, comparing the accuracy and reliability of the single pocket method against the four pocket method through a rigorous validation process.
Aim: To leverage cutting-edge ultrasound technologies to provide a detailed analysis of how alterations in AFI may affect fetal well-being in distinct trimesters and to compare the impact of mitigate potential fetal outcome of patients with 2nd and 3rd trimesters with abnormal amniotic fluid index (AFI) through ultrasound techniques.
Methods: This comparative prospective observational study was conducted at Gilani Ultrasound Centre, University of Lahore, from 30th November 2022 to 30th December 2023. After the approval of the gynaecology department and written informed consent of the patients, the data of 200 pregnant patients of the 3rd and 4th trimesters were analyzed. Ultrasound Doppler machines were utilized for research purposes, although AFI levels were measured at 3rd and 4th trimesters of pregnancy. Increased and decreased AFI levels and fetomaternal outcomes were monitored.
Results: In the single pocket method, 24 out of 100 cases exhibited abnormal Amniotic Fluid Index (AFI), with 16 cases classified as polyhydramnios and 8 cases as oligohydramnios. Conversely, in the four pocket method, 46 out of 100 cases had abnormal AFI, with 22 cases identified as polyhydramnios and 24 as oligohydramnios. The mean gestational age for the overall cohort of 200 females was 26.87. Within this group, the largest pocket volume in the single-pocket method had a mean AFI of 5.24±2.3, while the four-pocket method exhibited a mean AFI of 13.38±4.5. Results also indicated no association between foetal outcomes and abnormal AFI in patients undergoing standard ultrasonography strategies, as p-value > 0.05.
Conclusion: Phelan's and Chamberlain's methods demonstrate noncomparable precision in assessing amniotic fluid index (AFI) during the second and third trimesters of pregnancies. The findings also suggested that there is no association between foetal outcomes and abnormal Amniotic Fluid Index (AFI) in patients who undergo Phelan's and Chamberlain's ultrasonography strategies.
Keywords: amniotic fluid index (AFI), the largest vertical pocket (LVP), PIH, PROM

INTRODUCTION

The amnion, a membrane closely enveloping the embryo, undergoes expansion as it fills with amniotic fluid, transforming into the amniotic sac.[1]This fluid, initially colorless, steadily increases in quantity, leading to the amnion's adherence to the inner surface of the chorion. Produced as early as 12 days post-conception by the cellular wall of the amniotic sac, the amniotic fluid evolves during the first trimester, primarily deriving from blood plasma diffusing through fetal tissues. By around 20 weeks, the fetal kidneys become functional, and fetal urine becomes the predominant source of amniotic fluid.[2,3] The fluid undergoes continuous renewal, replacing itself approximately every 3 hours. Its volume gradually escalates until 28-32 weeks, remaining constant until 38-40 weeks, after which it decreases following term[4].



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During the second and third trimesters, approximately around the 14th week, the amniotic fluid undergoes a compositional change, incorporating proteins, carbohydrates, lipids, phospholipids, and urea[5]. Concurrently, the fetal kidneys become operational in the second trimester, adding to the overall volume of the amniotic fluid. Notably, as pregnancy progresses, the baby initiates the process of breathing and swallowing the amniotic fluid, signifying an increasing significance during later stages of gestation[6].

Oligohydramnios denotes a relatively decreased volume of amniotic fluid during pregnancy[7]. Conversely, an excessive amount of amniotic fluid, particularly considering the stage of birth, is termed polyhydramnios, also known as hydramnios. The development of polyhydramnios can occur suddenly or gradually over time. Sudden polyhydramnios is often associated with a severe second-trimester condition marked by the rapid accumulation of fluids, albeit for a brief duration[8]. On the other hand, enduring polyhydramnios typically commences in the third trimester, progressively increasing in both size and duration[9].

Ultrasound serves as an exceptional non-invasive imaging modality, commonly employed to yield accurate diagnostic information regarding amniotic fluid volume and the management of deviations in amniotic fluid levels, thereby minimizing fetal and maternal risks[10,11]. Three methods are commonly used for assessing amniotic fluid volume. The Chamberlain or Single Deepest Pocket method involves measuring the largest vertical pocket of amniotic fluid, ranging from 2 to 8cm[13]. This method has been utilized as a standalone test, and studies by Chamberlain, Dean, and others have indicated that when the largest vertical pocket (LVP) measures less than 1cm, perinatal morbidity increases and when it falls below 90.5cm, the perinatal mortality rate rises[14].

The Phelan method, also known as the four quadrant amniotic fluid index, divides the uterus into four compartments with

the umbilicus as the center. In each quadrant, the largest vertical pocket is measured, and these measurements are summed. The resulting values range between 8.1cm and 18.0cm³, defining the Four Pocket method.[15]The Amniotic Fluid Index (AFI) serves as a pivotal mechanical cushion and antibacterial agent during the 2nd and 3rd trimesters, possessing bacteriostatic properties that safeguard against potential infections. Not only does it contain nutrients and growth factors, but it also functions as an indicator of fetal growth and supports antenatal fetal surveillance. International studies have previously explored deviations in AFI concentrations during the 2nd and 3rd trimesters, revealing potential adverse outcomes. To mitigate the diverse risks associated with oligohydramnios and polyhydramnios, the adoption of advanced ultrasound technologies is crucial, helping to avert severe outcomes linked to fetal maturity and impairments in the gravid woman's ability to combat infections. Additionally, recognizing the standardized approach for measuring AFI is vital, offering a comprehensive understanding of how variations in AFI may impact fetal health during these distinct stages of pregnancy. The findings of this study may hold implications for refining prenatal care protocols and enhancing the early detection and management of conditions influencing fetal well-being.

MATERIALS AND METHODS

This comparative prospective observational study was conducted at Gilani Ultrasound Centre, University of Lahore, from 30th November
examinations aged ≥20 years were calculated by using a 1% level of significance while 99% power of test by using amotic fluid index level in both Phelan's and Chamberlain's methods 14.66±2.8 vs. 14.09±0.33. Pregnant females with diabetes mellitus, hypertension, ultrasonographically detectable anomalies, premature rupture of membranes, intrauterine growth retardation, and any known foetal abnormalities were excluded from the study.

Informed consent will be taken from every patient. Demographic information (like name, age, sex, height, weight, and address) will also be obtained. They will be categorised into two techniques: 100 cases in group A as Chamberlain (single deepest pocket) and 100 cases in group B as Phelan (4 pockets) for AFI estimation computed by during Xario and Z-5 ultrasound Doppler machines by presence of transabdominal (3.5–5 MHz) probes. AFI values with a cut of value (5 to 18 cm) are considered normal, although < 8.1 was considered oligohydramnios and > 18 was considered polyhydramnios. Each patient transabdominal ultrasound was carried out in supine position, applied coupling gel to the lower abdomen, and monitored in the 2nd and 3rd trimesters.

Chamberlain (single deepest pocket) method determined by (3.5 MH) and (5 MH) frequencies; in this method, a cut of value < 1 cm reported as oligohydramnios and > 8 cm as polyhydramnios; at the same time, the Phelan method expressed as radiographers measure the depth of amniotic fluid in for quadrants in the uterine cavity and sum them up to together; a value <8.1cm was considered as oligohydramnios and >18cm as polyhydramnios[11]. The endpoint of the study was clinically suspected fetomaternal outcome.

PIH was defined as ACOG guidelines determined by systolic blood pressure exceeding 140mmHg and diastolic pressure surpassing 90mmHg; Macrosomia, indicated by foetal weight exceeding 4000g and PROM, identified through vaginal bleeding, are additional diagnostic criteria. PROM diagnosis involves a pH test yielding a value greater than 7.3. Malpresentation is defined as a breech presentation, assessed through an external cephalic version (ECV) supported by ultrasound. Chronic abruption is determined by measuring anterior placental thickness, with a cut-off value for maximum depth at 4.5 cm, and noting a central sonolucent area measuring 4.7cm×1.6 cm. Prolonged pregnancy extends beyond 42 weeks (294 days) from the first day of the last menstrual period. IUGR is detected through foetal heart rate monitoring, with a cut-off value exceeding 200 beats per minute. Diabetes mellitus criteria include fasting plasma glucose levels of 5.1-6.9mmol/l (92-125mg/dl) and 1-hour post-75g oral glucose load levels equal to or exceeding 10.0mmol/l (180mg/dl). Preterm labour is defined as cervical length measuring less than 5 mm, determined by a pelvic exam. Twin pregnancy is calculated based on an hCG level exceeding 25 U/L. Cord prolapse is identified by bradycardia with a cut-off value of less than 120 foetal beats per minute. Rh incompatibility is measured through ABO testing for positive foetalRhD genotyping with fetomaternal outcomes closely monitored. The collected data was analysed statistically by using SPSS version 26. Continuous variables were presented in form of mean ± S.D. Categorical variables were presented in form of frequency and percentages. Chi-square test was applied to test the association of the disturbed amniotic fluid levels with the occurrence of fetus outcome with both techniques (Phelan and Chamberlain methods) while for < 5 cell frequency fisher exect test was applied, continuous variables were analyzed by the independent sample t – test.P value≤0.05 was taken as significant. All test was applied as a two-tailed

RESULTS

Among the 200 patients in our study, we identified that 47% of females were in the second trimester and 53% of females were in the third trimester, resulting in the patients in the population in the third trimester being greater than the second trimester. In the single-pocket method, out of 100 cases, 16 had abnormal amniotic fluid index (AFI), 8 were polyhydramnios, and 8 patients were detected as oligohydramnios. In the four-pocket method, out of 100 cases, 30 had abnormal amniotic fluid index (AFI), 18 were polyhydramnios, and 12 patients were detected as oligohydramnios, while the accuracy of the SVP was found to be less as SVP method as compared to FVP has been demonstrated to be a statistically significantly non-effective technique for AFI preservation as it has high sensitivity and specificity when detecting an abnormal volume (84% and 72%).

Table-1: Inferential statistics of different Ultrasound techniques presentation of the patient with respect to the demographical characteristics.

Characteristics		Ultrasound techniques		P-Value
		Chamberlain (Single Pocket) n=100	Phelan (Four Pocket) n=100	
Gestational Age		26.65 ± 6.9	28.28 ± 6.1	0.322
Blood Pressure	Normal	42/100	36/100	0.008 4
	Low	8/100	24/100	
	High	50/100	40/100	
Trimester	2nd Trimester	47/100	42/100	0.57
	3rd Trimester	53/100	58/100	
Parity	Prim gravida	36/100	24/100	0.089
	Multigravida	64/100	76/100	
AFI	Normal	84(84%)	70(70%)	0.14
	Abnormal	16(16%)	30(30%)	

Table-2: Difference between Classification of the patients on the basis of increase and decrease AFI obtained by Chamberlain (Single Pocket) and Phelan (four pocket) method.

AFI	Chamberlain (Single Pocket) n=100	Phelan (Four Pocket) n=100	P-value
Normal	84/100	70/100	0.001
Oligohydramnios	8/100	12/100	
Polyhydramnios	8/100	18/100	

The mean gestational age for 200 females was 26.87. Among them, the largest pocket volume had a mean AFI of 5.24±2.3, while in the four-pocket method, the mean AFI was 13.38±4.5.The study found that the mean gestational age in the second and third trimesters was 20.47±3.6 vs. 32.55±2.7, with a p-value was statistically significant at 0.001. In the single-pocket method, the gestational age in second and third trimesters was 5.336 ± 2.10 vs.

5.13±2.47 p-value of 0.618. On the other hand, in the four-pocket method, the gestational age in the second and third trimesters was 13.28±4.01 vs. 13.48±5.06: p-value of 0.841. Table 2 showed that there is no association of fetural outcome with abnormal AFI in patients undergoing standard ultrasonography strategies. However, the correlation between single and four pocket AFI levels was lower, as r = 0.377 with a P-value of 0.001 (Fig. 1).

Table-3: Association on the basis of AFI obtained by Ultrasound techniques with clinical fetomaternal outcomes

Outcomes	AFI	Ultrasound techniques		Total	p-value
		Chamberlain (Single Pocket)	Phelan (Four Pocket)		
PIH	Oligohydramnios	1/8	2/12	3/20	1.00
	Polyhydramnios	8/8	7/18	15/26	
Prom	Oligohydramnios	4/8	3/12	7/20	0.386
	Polyhydramnios	9/8	18/18	27/26	
Malpresentation	Oligohydramnios	4/8	8/12	12/20	0.237
	Polyhydramnios	5/8	8/18	12/26	
Chronic abruption	Oligohydramnios	0	0	0	1.00
	Polyhydramnios	0	0	0	
Prolonged pregnancy	Oligohydramnios	4/8	6/12	10/20	1.00
	Polyhydramnios	0/8	0	0	
Iugr	Oligohydramnios	6/8	8/12	14/20	1.00
	Polyhydramnios	0	0	0	
Diabetes mellitus	Oligohydramnios	0	12/12	12/20	0.47
	Polyhydramnios	2/8	10/18	20/26	
Preterm labourn	Oligohydramnios	6/8	8/12	14/20	0.82
	Polyhydramnios	4/8	12/18	34/26	
Twin pregnancy	Oligohydramnios	0	0	0	1.00
	Polyhydramnios	4/8	3/18	7/26	
Cord prolapsed	Oligohydramnios	0	0	0	1.00
	Polyhydramnios	2/8	3/18	5/26	
Rh incompatibility	Oligohydramnios	0	0	0	1.00
	Polyhydramnios	3/8	2/18	5/26	

DISCUSSION

The amount of amniotic fluid acts as a key indicator of the fetus's health inside the womb. Therefore, its quantification is crucial in determining the fetus's state. The terms polyhydramnios and oligohydramnios, which refer to an excess and a deficit of amniotic fluid, respectively, may arise if there is a mismatch between these compartments[9]. The aims to observe the role of ultrasound in assessing amniotic fluid in the second and third trimesters of normal pregnancies. Abnormalities in amniotic fluid volume are associated with a variety of pregnancy complications, so it is important to assess amniotic fluid index either qualitatively or quantitatively at every antenatal ultrasound examination as accurate fluid assessment prevent the fetus outcome. The ultrasound techniques commonly used to estimate amniotic fluid volume include the Chamberlain method and the Phelan method thus we may assume that both Chamberlain and Phelan approach is appropriate for patients with an increased risk.

A study performed by Yousaf S, Naeem MA[17] concluded that the MVP technique was superior in diagnosing abnormal AFV as compared to SVP (72/1168 vs. 32/1168). Another study by[9,13] analyzed that MVP technique is a better choice when evaluating AFV in contrast to SVP, which must accurately identify the actual oligohydramnios or polyhydramnios. Present study showed similar results reported MVP technique was superior in diagnosing abnormal AFV as compared to SVP showed the difference was statistically significant as (16% vs. 84%) and (30% vs. 70%) while according to the results of the study[16] scrutinized both Phelan and Chamberlain methods are commonly used ultrasonography techniques for amniotic fluid assessment.

Further study by[13,18,20] found that both techniques were unreliable in the detection of abnormal AFV and that neither technique was superior to the other. Gunasingha H, Hemapriya S[18] demonstrated that SVP measurement is the method of choice for the assessment of AFI, whereas is no evidence that one method is superior to the other. The author[12] determined that either of the two techniques is to be acknowledged as superior to the other unveiled dissimilar results due to different diagnostic criteria used and other factors i.e., experience of operators, fetal position, presence of abdominal mass or scar could interfere with an adequate measurement.

Precise evaluation and identification of abnormalities in (AFI) equip physicians with essential information for the comprehensive management of a pregnancy over time, potentially enhancing the overall outcome.Our results support that gestational age at second and third trimester did not differ between the two groups(26.65 ± 6.9vs. 28.28±6.1, p>0.05), although[19] reported similar results as (277±7.60 vs. 274.87±8.93, p=0.08).The determined different results as gestational age at second and third trimester did not differ between the two groups were 267.98± 7.18 vs. 274.04± 6.18 days[18].

Present study showed that FVP has been demonstrated to be non-effective technique for detecting of adverse outcome as is attributed to its high sensitivity (84%) and specificity (72%) in detecting abnormal volumes while showed similar results for both groups as accuracy (70%) p-value <0.05. Another study by[21]established that ultrasound used by (SDVP) method has been proven to be effective technique in preventing adverse outcomes, attributed to the high sensitivity and specificity (90%) of the ultrasound in detecting abnormal volumes. similar results were observed for both groups, as indicated by a p-value of <0.05. Magann[13,20] et al evaluated that SVP considerably accurate procedure as high sensitivity and specificity for detecting abnormal AFI (72% to 44%) dissimilar results due to many possible confounding factors which can affect AFI and SDVP value such as parity, maternal age, anatomy and anthropometry.

The findings of the current study underscore the effectiveness of the (MVP) technique in ensuring reliable and accurate assessment of amniotic fluid index (AFI), establishing it as a robust predictor of adverse fetomaternal outcomes. Conditions such as Pregnancy-Induced Hypertension (PIH), prolonged pregnancy, Intrauterine Growth Restriction (IUGR), RH incompatibility, and cord prolapse exhibited similar occurrences in both groups. However, statistically significant differences were observed in the incidence of preterm labor, Diabetes Mellitus, malpresentation, and Premature Rupture of Membranes (PROM). The research conducted by[4] concluded that the MVP method, when compared to the (SVP) technique, demonstrated equivalent predictive capabilities for adverse outcomes. Additionally, The author[19] emphasized the MVP technique's accuracy in identifying adverse fetomaternal outcomes when contrasted with the SVP method while[18-22] reported dissimilar results due to depending upon

the different visual assessments and different techniques of measurement, the normal range of AFI may vary from one population to the other populations and small sample size. The study included participants from various age groups, and despite the exclusive selection of singleton pregnancies, there was variability in parity among them. The study did not undertake the restriction or categorization of participants based on anthropometric differences such as height, weight, and BMI. The study design had limited opportunities to address confounding factors and ensure their even distribution, factors that could potentially influence the study outcomes.

CONCLUSION

Phelan's and Chamberlain's methods are almost equally precise techniques in AFI assessment in uncomplicated singleton pregnancies. Assessment of amniotic fluid index (AFI) was found to be completely disparate while there is no specific preference regarding association of adverse clinical outcome between increased vs. decreased AFI in the population under study by owning standard ultrasonography strategies.

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1. Conception and design of or acquisition of data or analysis and interpretation of data.
2. Drafting the manuscript or revising it critically for important intellectual content.
3. Final approval of the version for publication.

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