Article published online: 2023-05-08

J. Fetal Med. (June 2015) 2:61–67
DOI 10.1007/s40556-015-0049-8

ORIGINAL ARTICLE

Aminotic Fluid Index and its Correlation with Fetal Growth and Perinatal Outcome

Sonia Madaan[1] · Suman Lata Mendiratta[1] · Pawan Kumar Jain[2] · Meenakshi Mittal[1]

Received: 25 March 2015 / Accepted: 29 July 2015 / Published online: 28 August 2015

Abstract The present study aimed to measure amniotic fluid index (AFI) in high-risk pregnancies at ≥30 weeks of gestation and its correlation with fetal growth and perinatal outcome. The Study was carried out in the Department of Obstetrics and Gynecology Hindu Rao Hospital, Delhi. Ultrasound examination was done on women with high-risk pregnancy (pregnancy-induced hypertension, intrauterine growth restriction, diabetes, and postdated pregnancy etc.) attending the antenatal OPD and maternity ward at ≥30 weeks of gestation. AFI was measured by the four quadrant technique. The study included 48 (48 %) primigravida and 52 (52 %) multigravida. Sixteen patients with a history of previous abortion had mean AFI of 9.97 cm which was lower than patients with no history of previous abortion i.e., 11.87 cm ($P \geq 0.1$ insignificant). The mean AFI was maximum between 34–36 weeks, i.e., 13.1 cm, after which, it gradually decreased to 9.08 cm beyond 40 weeks. Mean AFI of patients with <40 weeks of gestation gradually decreased from 12.2 cm to 8.0 cm after 42 weeks (P value <0.05). Patients with IUGR had low mean AFI i.e., 9.8 cm whereas mean AFI in patients without IUGR was 12.1 cm (P value <0.01). Congenital anomalies were found in 4 % patients in the present study. Out of seven cases of perinatal mortality encountered, four (57 %) had abnormal AFI values, of which, two had low AFI (i.e., <8 cm) and two had abnormally-high AFI values i.e., >18 cm. Serious congenital malformations were present in three neonates, which resulted in early neonatal death. Out of these three, one patient had low AFI i.e., <8 cm and one had abnormally-high AFI value i.e., >24 cm. The study supports the view that AFI is a quick, noninvasive, and good indicator of fetal outcome in high-risk pregnancy.

Keywords Amniotic fluid index (AFI) · Oligohdramnios · Polyhdramnios · IUGR · Perinatal outcome · High-risk pregnancy

Introduction

Amniotic fluid acts as a protective layer which exerts a cushion-like effect for the growing fetus against mechanical and biological injury. Amniotic fluid may be regarded as the largest part of the fetal extracellular space, and it provides a more accessible means than fetal blood for investigation of the fetus and its environment. Amniotic fluid assessment is an integral part of the antenatal evaluation of pregnancies at risk for an adverse pregnancy outcome especially in the third trimester [1, 2]. Detecting the fetus at risk for in utero damage or death, quantifying, and balancing the fetal risk against the risk of neonatal complications from immaturity, and determining the optimal time and mode of intervention are the cornerstone of modern day obstetrics care and perinatal medicine [3].

Reduced amniotic fluid volume (AFV) is associated with adverse effects such as meconium staining, congenital anomalies, growth retardation, dysmaturity, and fetal asphyxia [4–6]. Polyhydramnios is sometimes associated with major fetal anomalies [5], aneuploidy, macrosomia, and stillbirth [6]. Decreased AFV in those pregnancies

✉ Suman Lata Mendiratta
sumanmendi@yahoo.co.in

1 Obstetrics & Gynaecology Department, North DMC Medical College & Hindu Rao Hospital, A-3/224, Janakpuri, New Delhi 110058, India

2 Radiology Department, North DMC Medical College & Hindu Rao Hospital, New Delhi, India

without premature rupture of the membranes can reflect a fetus in chronic stress, shunting of blood to its brain, adrenal and heart and away from other organs, which include the kidney, and results in decreased fetal renal perfusion and urinary output. Phelan et al. [7] have recommended that labor induction be considered in patients with oligohydramnios (AFI < 5 cm) to reduce the increased risk of fetal death and morbidity. An antepartum amniotic fluid index (AFI) of 5 cm or less is a predictor of adverse perinatal outcome in terms of meconium staining, cesarean section for fetal distress, birth weight, low Apgar scores and cord pH [8]. AFI of >18 cm is taken as cut-off point for normal limit of AFI. Pregnancy complicated with polyhydramnios is also classified as high risk. AFV can be measured by dye-dilution techniques and by direct quantification at the time of cesarean delivery, but both methods are invasive, require laboratory support, and when measured at the time of operative abdominal delivery, cannot be used serially to evaluate high-risk pregnancies [1]. The limitation of the direct AFV measurement led to the use of ultrasonic AFV estimation. Ultrasonography is noninvasive and can clinically quantitate the AFV. There are various reported ultrasonographic modalities to assess AFV like (1) single deepest pocket (2) 2-diameter pocket, and (3) AFI by 4-quadrant method. Since the introduction of AFI by Phelan et al. [7], a rapid semi-quantitative assessment of AFV can be performed quickly, is easily taught, and is reproducible.

AFI also facilitated the diagnosis of a congenital anomaly not detected in referring clinics. The antepartum information regarding malformation was valuable for the patients and their health-care providers in deciding on the timing and mode of delivery, determining an etiology of intrauterine or postnatal death, and counseling of future pregnancies. The present study was aimed to measure AFI in high-risk pregnancies ≥30 weeks of gestation and its correlation with fetal outcome.

Materials and Methods

This was a one year prospective study undertaken in the department of Obstetrics and Gynecology, Hindu Rao Hospital, Delhi a period of one year, after obtaining ethical clearance from institutional committee. Ultrasound examination was done on women with high-risk pregnancy (pregnancy-induced hypertension, intrauterine growth restriction, diabetes, and postdated pregnancy etc.) attending the antenatal OPD and maternity ward at ≥30 weeks of gestation. Only patients who were sure of dates were included in the study. Patients with premature rupture of membranes and twin pregnancy were excluded from the study.

A detailed history was taken and a general physical and obstetrics examination were done. The patient was then subjected to ultrasonographic examination. Routine scan for fetal well being was done and AFI was measured by the 4-quadrant technique [7]. The vertical diameter of the maximum pocket was measured in centimeters in each of the four quadrants and measurement obtained from each quadrants were summed to form the AFI in centimeters.Follow-up of these patients was done till delivery and their neonatal outcome was noted in terms of fetal distress in labor, birth weight, Apgar at five minutes, congenital anomalies, and perinatal mortality. The results were compiled and analyzed.

Results

The present study was conducted on 100 antenatal patients over a period of one year. All the 100 patients included in the study had attended antenatal OPD/maternity ward at Hindu Rao Hospital and delivered at the Labor Room in Hindu Rao Hospital and the results were analyzed as follows.

The majority of cases i.e., 62 (62 %) were in the age group of 21–25 years, followed by 27 (27 %) in the age group 26–30 years, and the least were among the age group >31 years (2 %). The mean age for the entire study population was 24.31 years. The mean AFI for all age groups was 11.567 ± 5.364 cm. Present study included 48 (48 %) primigravida and 52 (52 %) multigravida.

The maximum cases i.e., 36 (36 %) had a gestational age between 36 to 38 weeks at the time of enrollment. The mean AFI was maximum, between 34–36 weeks i.e., 13.1 cm, after which, it gradually decreased to 9.08 cm beyond 40 weeks (Table 1). Mean AFI of patients with <40 weeks of gestation gradually decreased from 12.2 cm to 8.0 cm after 42 weeks (P value <0.05) implies significant relationship between post-term pregnancy and AFI.

Antenatal complications in the present study group show that anemia (Hb < 10 g %) was the commonest complication found in 27 % cases, followed by IUGR (24 %), PIH (20 %), previous abortions (16 %) cases, previous lower segment cesarean section (11 %), oligohydramnios (8 %), post-term pregnancy (6 %), and polyhydramnios (5 %) being the next common complications (Table 2).

Mean AFI of patients with IUGR was 9.8 cm whereas that in patients without IUGR was 12.1 cm, implies a highly-significant relationship between IUGR and AFI. It was found that out of 20 patients who were hypertensive, 8 (40 %) had low AFI i.e., <8 cm. The mean AFI of hypertensive patients was 10.7 cm which was not significantly different, statistically, from mean AFI of

Table 1 Distribution of patients according to gestation age at enrollment

POG at enrollment (weeks)	No. of patients	Mean AFI (cm)	SD
30–32	1	4.000	–
32–34	4	9.200	1.860
34–36	15	13.133	7.067
36–38	36	12.908	5.602
38–40	24	11.354	4.977
>40	20	9.085	2.948
Total	100	11.567	5.364

AFI amniotic fluid index, *POG* period of gestation, *SD* standard deviation

Table 2 AFI in various high-risk pregnancy groups (some cases had more than one high-risk factor)

High-risk pregnancy factor	No. of cases (out of 100)	Mean AFI (cm) in cases	Mean AFI (cm) in controls	SD
IUGR	24	9.821	12.118	5.650
Hypertension	20	10.740	11.774	4.859
Anemia	27	11.637	11.541	2.690
Previous LSCS	11	11.864	11.530	6.581
Post-term > 40 wks	20	9.085	12.188	2.948
Diabetes	5	12.300	11.528	5.709
Rh-negative	5	12.840	11.500	2.806
Previous abortions	16	9.97	11.870	2.617

AFI amniotic fluid index, *IUGR* intrauterine growth restriction, *LCSC* lower segment cesarean section, *SD* standard deviation

normotensive patients i.e., 11.7 cm. The mean AFI in patients with anemia was 11.63 cm which was not significantly different from patients without anemia i.e., 11.54 cm. There was no disparity between AFI in pregnancies with previous LSCS and non-LSCS group, mean AFI being 11.864 and 11.530 in cases and controls, respectively. Mean AFI of patients <40 weeks gradually decreased from 12.2 cm to 9.085 cm at >40 weeks and 8.0 cm after 42 weeks. There is no significant relation between diabetes mellitus and AFI, though mean AFI in pregnancies with diabetes (12.3 cm) was found to be more than those without diabetes (11.5 cm). Mean AFI in Rh-negative pregnancies was 12.8 cm which was slightly higher than rest of the cases i.e., 11.5 cm. The mean AFI of 16 patients with a history of previous abortion was 9.97 cm which was lower than those with no history of previous abortions i.e., 11.87 cm.

Table 3 depicts the relation of clinical assessment of liquor to the AFI obtained ultrasonographically. Mean AFI of 65 patients with clinically-normal liquor was 11.9 cm; mean AFI of 27 patients with clinically-less liquor was 6.7 cm and mean AFI of eight cases with clinically-more liquor was 24.3 cm. Statistical tests were applied and it was found that clinical estimation of liquor has a sensitivity of 74.35 % and a specificity of 90.16 %, the accuracy being 84 %. Table 4 depicts AFI in relation to delivery outcomes.

Discussion

The present study was undertaken to measure AFI in high-risk pregnancies and to correlate it with fetal outcome. The mean maternal age in this study was 24.31 ± 3.19 years. Magann et al. [9, 10] in 1999 and 1997 reported the mean

Table 3 Comparison of AFI and clinical assessment of liquor (by palpation)

Clinical assessment of liquor	No. of cases	%	Mean AFI	SD
Normal	65	65	11.975	3.417
Less	27	27	6.785	1.789
More	8	8	24.388	3.272
Total	100	100	11.567	5.364

$P \leq 0.001$ (very highly significant)

Table 4 AFI in relation to delivery outcomes

Mode of delivery in relation to AFI[a]

Mode of delivery	No. of cases	%	Mean AFI (cm)	SD
Normal	63	63	12.162	4.999
Forceps	8	8	9.663	5.808
Cesarean	29	29	10.800	5.959
Total	100	100	11.567	5.364

Labor (spontaneous or induced) in relation to AFI[b]

Labor	No. of cases	%	Mean AFI	SD
Spontaneous	54	98.35	11.976	4.385
Induced	25	31.64	11.024	6.255
Total	79	100	11.675	5.030

AFI in relation to meconium staining of liquor[c]

Meconium staining of liquor	No. of cases	%	Mean AFI	SD
Absent	85	85	11.754	5.020
Present	15	15	10.507	7.131
Total	100	100	11.567	5.364

Relation of AFI with fetal heart rate[d]

FHR	No. of cases	%	Mean AFI	SD
Normal	84	84	11.429	4.841
Bradycardia	12	12	11.975	7.507
Tachycardia	4	4	13.250	9.465
Total	100	100	11.567	5.364

AFI and its relation to birth weight[e]

Birth weight (g)	N	%	Mean AFI	SD
<2000	17	17	7.976	2.467
2001–2500	27	27	12.448	6.526
2501–3000	43	43	12.247	4.106
>3000	13	13	12.185	7.476
Total	100	100	11.567	5.364

Apgar (5 min) versus AFI[f]

Apgar	N	%	Mean AFI	SD
<9	10	10	11.550	8.448
9–10	90	90	11.569	4.976
Total	100	100	11.567	5.364

Congenital anomalies in the study group[g]

Congenital anomaly	Number	AFI (cm)
Bilateral CTEV	1	6.3
Osteogenetis imperfecta	1	7.0
Fetal ascites + treacheoesophageal interval + laryngeal stenosis	1	26.0
Tracheoesophageal fistula + anal agenesis	1	10.0

Table 4 continued

AFI versus perinatal mortality[h]			
Perinatal mortality	AFI (cm)		
	<8	8–18	>18
Fresh stillbirth	–	–	1
Neonatal death	2	3	1

AFI amniotic fluid index, *CTEV* congenital talipes equinovarus, *FHR* fetal heart rate, *SD* standard deviation

[a] Mean AFI in patients undergoing assisted delivery was found to be lower (9.66 cm in forceps and 10.8 cm in cesarean group) than mean AFI in patients undergoing normal delivery (i.e., 12.16 cm). It was also found that among 28 patients who had low AFI, 6 patients (42 %) had forceps delivery whereas 13 (46.42 %) had cesarean section

[b] The commonest cause of induction of labor in the study group was PIH (32 %), IUGR (16 %) and post-dated pregnancy (12 %)

[c] $P \geq 0.1$. The mean value of AFI (10.5 cm) in patients with meconium staining of liquor was not significantly different from those without meconium staining of liquor (11.7 cm). $P \geq 0.1$ (not significant)

[d] $P \leq 0.1$ (not significant). There was no correlation between the FHR and AFI. Out of 28 patients with low AFI, six (21.42 %) had fetal bradycardia and two (7.14 %) had fetal tachycardia

[e] $P \leq 0.05$ (significant relation). Mean AFI was found to be significantly lower (7.9 cm) in low birth weight group <2000 g (P value < 0.05), implies significant relation between birth weight and AFI

[f] $P \geq 0.1$ (not significant). Mean AFI in patients with APGAR <9 was not found to be significantly different from mean AFI in patients with Apgar >9

[g] Congenital anomalies were found in 4 % patients in our study. The salient feature noted was that three (75 %) out of these four cases had abnormal AFI scores, two cases had low AFI scores (<8 cm) and one had high AFI value (>24 cm) while mean AFI of the remaining study group was 11.54 cm

[h] Out of seven cases of perinatal mortality encountered in our study, four (57 %) had abnormal AFI values, of which two had low AFI (i.e., <8 cm) and two had abnormally-high AFI values (i.e., >18 cm). Three neonates had serious congenital malformations which resulted in early neonatal death, of which one patient had low AFI (i.e., <8 cm) and one had abnormally-high AFI value (i.e., >24 cm)

maternal age of 24.8 ± 5.3 and 24.5 ± 0.5 years, respectively, which was comparative to our study. In our study parity has no relation to the distribution of cases as was seen in the study conducted by Magann et al. [10].

In our study anemia was the commonest complication, seen in 27 (27 %). Other significant complications were IUGR (24 %), PIH (20 %), previous LSCS (11 %), oligohydramnios (8 %), post-term pregnancy (6 %), and polyhydramnios (5 %). Magann et al. [11] reported IUGR in 4.74 %, PIH 3.16 %, and post-term pregnancy in 24.65 % patients. Golan et al. [12] reported IUGR in 24.5 % and hypertension in 22.1 %. In our study, among 27 % cases that had anemia, no correlation was found between anemia and AFI.

In our study, out of 29 patients with AFI < 8 cm, 12 (41.4 %) patients had IUGR. O'Brien et al. [13] concluded that fetal growth retardation is significantly associated with an AFI of 7 cm, or less ($P \leq 0.001$).

In the present study, 20 (20 %) patients were hypertensive. Out of these patients, eight (40 %) had low AFI scores (<8 cm). In a study conducted by O'Brien et al. [13], out of 14 patients of mild PIH, only two patients i.e., 14 % had a low AFI score (≤7 cm). In a study by Magann et al. [14] on patients with AFI < 5 cm, 7.16 % patients were found to be hypertensive.

In this study, out of six patients with post-term pregnancy, oligohydramnios (AFI < 5 cm) was seen in 2 (33.3 %) cases. In a study conducted by Marks and Divon [14] on post-term pregnancy, oligohydramnios was demonstrated in 59 (11.5 %) patients. If diabetes is associated with macrosomia and neural tube defects, polyhydramnios may develop. In our study, it was observed that mean AFI of five patients with diabetes was more (12.3 cm) than nondiabetic patients (11.5 cm) though it was not statistically significant (P value ≥ 0.1).

In the present study, AFI according to gestational age was studied. The mean AFI was 11.567 cm. Maximum AFI of 13.13 cm (mean) was seen at 34–36 weeks of gestation, which gradually decreased to 9.085 (mean) after 40 weeks. Similarly, Phelan et al. [7] demonstrated a mean AFI of 12.9 ± 4.6 in 353 pregnancies at the gestational age ranging from 36–42 weeks. Bowen-Chatoor and Kulkarni [15] demonstrated a mean AFI of 9.93 ± 4.37 cm at 42 weeks, which is comparable to our study.

In our study, it was observed that mean AFI of five patients with Rh-negative pregnancy was more i.e., 12.84 cm than rest of patients i.e., 11.5 cm. Mean maternal weight in our study was 64.87 ± 9.66 kg, with majority of cases between 50–65 kg. Fifty four (68.35 %) patients had spontaneous onset of labor while 25 (31.64 %) were induced. The main indication for induction was PIH, IUGR followed by postdated pregnancy.

In this study, out of 29 patients with low AFI (<8 cm), six (20.7 %) had forceps delivery, whereas 13 (44.8 %)

patients had cesarean section. Out of 61 patients with normal AFI, 47 (77 %) had normal delivery. According to Rutherford et al. [16], incidence of cesarean section was 58 % in patients with AFI < 8 cm which is slightly more than our study. Their cesarean section rate in patients with AFI > 18 cm was 41 %, which was low (30 %) in our study.

In our study, 15 cases had meconium-stained liquor, out of which eight (53.33 %) had low AFI scores (≤ 8 cm). In a study by Golan et al. [12], a high incidence of meconium staining of liquor (29.1 %) was seen in oligohydramnios. In another study by Magann et al. [11], meconium-stained amniotic fluid was seen in 13.8 % patients with AFI ≤ 5 cm. In our study, out of eight patients with low AFI (≤ 5 cm), two (25 %) had fetal bradycardia. In a similar study by Magann et al. [11], it was found that in patients with AFI < 5 cm, 24 % patients had fetal bradycardia, which was comparable to our study.

In our study, out of 29 patients with low AFI (≤ 8 cm), 17 (58.62 %) had low birth weight babies (≤ 2500 g). In 10 patients with AFI > 18 cm, five (50 %) had low birth weight babies. Martinez-Frias et al. [17] also observed similar results in their study. According to Chauhan et al. [18], AFI of <5 cm is associated with an increased risk of low (<7) Apgar score.

In our study, four patients had babies with congenital anomalies, out of which, two (50 %) had low AFI < 8 cm and one had AFI > 18 cm. In the study conducted by Martinez- Frias et al. [17] on malformed newborns, 3.01 % had oligohydramnios. Renal anomalies and lung defects were associated with oligohydramnios. They reported polyhydramnios in 3.69 % cases in their study. Esophageal and gastrointestinal anomalies, neural tube defects, and other central nervous system malformations were associated with polyhydramnios. In our study, osteogenesis imperfecta and bilateral CTEV were associated with low AFI of <8 cm, and tracheoesophageal fistula was associated with AFI > 18 cm.

In our study perinatal mortality rate was 7 %. Of these seven cases, three babies (42.85 %) had serious congenital malformations, two cases (28.57 %) had low AFI of <8 cm and two cases (28.57 %) had AFI > 18 cm. Biggio et al. [19] reported 6 % perinatal mortality in their study of 370 women, which was comparable to our study.

Conclusion

Amniotic fluid provides a more accessible means than fetal blood for surveillance of the fetus and its environment. Amniotic fluid assessment is an integral part of the antenatal evaluation of pregnancies at risk for an adverse pregnancy outcome. Our study supports the view that AFI is a quick, noninvasive and good indicator of fetal outcome in high-risk pregnancy.

Funding None.

Compliance with Ethical Standards

Conflict of interest None.

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