Amniotic fluid index variations after amniocentesis, amnioinfusion and amnioreduction: preliminary data

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Summary

We studied the relationship between the ultrasonographically measurable variations in the amniotic fluid index (AFI) and actual changes in the amniotic fluid volume induced by three differing invasive procedures: genetic amniocentesis, amnioinfusion and amnioreduction.

We examined 50 patients, all between the 15th and 34th weeks of pregnancy, subdivided into three groups. The first group consisted of 33 women who underwent genetic amniocentesis, the second was of 11 patients submitted to amnioinfusion for oligohydramnios (AFI<5 cm), and the third was composed of 6 patients affected by hydramnios (AFI>20 cm) and treated with amnioreduction. In all cases AFI was measured before and after the invasive procedures and their variations (ΔAFI) were correlated to the actual quantities of liquid infused or extracted. All the procedures gave rise to statistically significant AFI changes. After genetic amniocentesis, the mean change was from 12.0 to 10.9 cm ($p<0.005$), after amnioinfusion from 3.1 to 10.6 cm ($p<0.0001$) and after amnioreduction from 33.1 to 22.0 cm. ($p<0.005$). However, a significant linear correlation between ΔAFI and the fluid volume variations actually induced was found for amnioinfusion ($y=0.236537+0.031465x$; $R^2=44.4\%$; $p<0.05$) and for amnioreduction ($y=-0.0584294+0.012008x$; $R^2=89.8\%$. $p<0.00001$). Only for amnioreduction is it possible, as proved by a multiple regression analysis, to improve the predictability of ΔAFI, taking into consideration together with the quantity of fluid aspirated, the value of the pre-procedure AFI ($R^2=92\%$; $p<0.05$).

Key words: Amniotic fluid index; Amnioinfusion; Amnioreduction; Amniotic fluid volume; Ultrasonography.

Introduction

The advantages of the estimation of amniotic fluid (AF) volume in the evaluation of fetal wellbeing have by now been extensively demonstrated [1, 2, 3, 4]. In particular, because of its easy applicability and reproducibility, the Amniotic Fluid Index (AFI) has become the most widely used semiquantitative method (5-6). Several attempts, using diluition techniques, have been made to correlate this index with the actual volume of amniotic fluid, but these have often provoked severe criticism [7-8] as to the reliability of the methods. The use of ultrasonically monitored invasive procedures to modify the amniotic fluid volume has reintroduced the possibility of correlating AFI with the volume of AF infused or extracted, especially in the case of oligohydramnios or hydramnios. Strong *et al.* [9] correlated the endoamniotic infusion of 250 ml. of physiological solution with a mean AFI increase of 4 cm. after the 36th week of pregnancy. For the same volume of fluid infused into patients with membrane rupture near to term, Chauhan [10] has shown an AFI increase of 5.8+/–2.6 cm. Sepulveda W. *et al.* [11] have obtained a significant correlation between fluid introduced and AFI leading to the calculation, for the infusion of 250 ml. between the 16th and the 28th weeks, of an AFI variation of around 11 cm.

The aim of this study was to examine the AFI variation caused by three different invasive procedures: 1) amniocentesis carried out for diagnostic purposes between the 15th and 26th weeks; 2) amnioinfusion for oligohydramnios from the 17th to the 34th weeks; and 3) amnioreduction for hydramnios between the 23rd and 33rd weeks.

Materials and Methods

The study was conducted on 50 patients, all undergoing, after informed consent, one of three different invasive procedures at the Department of Obstetrics and Gynecology at the University of Parma.

The first group consisted of 33 patients who underwent amniocentesis between the 15th and 26th weeks for determination of the fetal karyotype and of the amniotic alfa-FP (advanced maternal age) or to reveal DNA from infecting organisms by means of Polymerase Chain Reaction (suspected fetal infection). We submitted all the patients to a single ultrasonographically monitored invasive procedure, taking a mean 22.7 ml sample of AF (range: 16-45 ml) using a 20 gauge needle (Ecojet-Sifo, Bologna, Italy).

The second group was composed of 11 patients between the 17th and the 34th weeks of pregnancy, affected by oligohydramnios as defined by an AFI<5 cm, and submitted to amnioinfusion to allow for an optimal ultrasonographic observation of fetal morphology and to confirm any membrane rupture with the introduction of 10 ml of 20% solution of indigo carmine. In all cases, amnioinfusion was carried out under direct ultrasonographic control, with the infusion of a mean 229 ml (range: 103-315 ml) of a normal saline solution at 37°, at a speed varying between 30 and 50 ml/min. One patient underwent two amnioinfusions and thus the total number of procedures was twelve.

Six patients affected by hydramnios as defined by an AFI>20 cm, comprised the third group. In these cases it was decided to carry out amnioreduction to reduce both the maternal dyspnoeic symptoms and the complications associated with the excess of AF (i, e, preterm labour, abruptio placentae, premature rupture of membrane). Under ultrasonographic guidance, an epidural anaesthesia catheter (Minipack, System 4, Portex, Bologna, Italy) was inserted, using an 18 gauge needle, into the intrauterine site and connected to a continuous aspiration system (Haemovack, Cremascoli, Bologna, Italy) with a speed of 150-200 ml/hr. Aspiration was stopped when the AFI went below 20-25 cm, and only resumed if AF volume increased once more. Amniotic drainage was in any case suspended during the night hours. AFI was measured immediately prior to the opening of the drainage system and immediately after the closure of the system. Two patients underwent two amnioreductions, one five, during the last of which the system blocked, while the other three underwent only one procedure. On average 920 ml. of fluid (range: 30-2620 ml.) were aspirated per procedure; the total number of procedures was twelve. All the invasive procedures were done by only one operator (D.G.), while the measurements of AFI before and after all procedures were done by two operators (D.G., G.P.).

Statistical analysis was thus carried out taking into consideration 33 amniocenteses, 12 amnioinfusions and 12 amnioreductions; elaboration of data was by the Statgraphics programme (Statistical Graphic System, Cambridge, UK), calculating for each group the mean, the standard deviation and the 95% confidence intervals. A T-test was calculated for paired data of AFI before and after the invasive procedures. A linear and polynomial regression analysis was done between the amniotic fluid index variation (ΔAFI) and the quantity of fluid extracted or infused. A multiple regression analysis was then carried out between ΔAFI and the fluid infused or extracted, gestational age and pre-procedure AFI.

Results

The data relating to diagnostic amniocentesis are summarized in Table 1. There is a statistically significant variation in AFI before and after extraction: from a mean 12.04 cm to a mean 10.96 cm ($p<0.005$); an extraction of 22.75 ml gives a variation in AFI of –1.08 cm. However, the AFI means before and after the procedure are similar; in fact their confidence intervals overlap clearly (95%CI: 11.1-13.0 vs 10.1-11.9).

Table 2 shows the data relating to amnioinfusion, which also gave rise to a significant increase in AFI, from a mean 3.17 cm to a mean 10.60 cm ($p<0.0001$); for a mean infusion of 229.2 ml a mean ΔAFI of 7.45 cm was obtained.

The data referring to amniotic drainage are reported in Table 3, which shows a significant AFI reduction after the procedures, from 33.13 cm to 22.01 cm ($p<0.005$); a ΔAFI of –11.11 cm corresponds to a mean aspiration of 920 ml.

For neither fluid infused nor fluid aspirated did regression analysis lead to the description of the dependent variable (ΔAFI) as a polynomial expression of the independent variable. In contrast, the linear regression analysis between volume of fluid extracted or infused and the AFI variation revealed a good correlation for amnioinfusion ($y=0.236537+0.031465x$; $R^2=44.4\%$; $p<0.05$; Fig. 1) and a high one for amnioreduction ($y=-0.0584294+0.012008x$; $R^2=89.8\%$; $p<0.00001$; Fig. 2). However, for amniocentesis a significant linear correlation does not exist between the fluid extracted and the ΔAFI ($R^2=1.03\%$; $p=0.528$).

The linear multiple regression analysis between ΔAFI and fluid infused, together with pre-procedure AFI and gestational age calculated in days, did not prove to be of any significance (Table 4), which shows that these three parameters considered together give no better prediction of ΔAFI than does quantity of fluid infused considered separately. The same multiple regression analysis done for quantity of fluid aspirated (Table 5) shows significance as to the quantity of fluid and the pre-amnioreduction AFI, but not as to gestational age. Thus, eliminating gestational age, the equation describing the correlation between the variables becomes: ΔAFI = 4.968 + 0.007 (Amniotic Fluid volume extracted) – 0.271 (pre-procedure AFI).

Table 1. — *Amniotic Fluid Index Variation (ΔAFI) before and after 33 genetic amniocenteses*

Statistical Parameters	A.I. Before (cm)	A.F. Removed (ml)	A.I. After (cm)	ΔAFI (cm)
Mean	12.042	22.757	10.96**	–1.0818
Standard deviation	2.759	6.398	2.259	1.942
Range	6.8-20.4	16-45	6.6-19	-3.8/-6.9
95% C.I.	11.1-13.0	20.5-25.0	10.1-11.9	-1.77/-3.93

** p<0.005 (AI After vs AI Before)
A.I. = Amniotic Index
A.F. = Amniotic Fluid
95% C.I. = 95% Confidence Intervals

Table 2. — *Amniotic Fluid Index Variation (ΔAFI) before and after 12 amnioinfusion procedures*

Statistical Parameters	A.I. Before (cm)	F.V. Infused (ml)	A.I. After (cm)	ΔAFI (cm)
Mean	3.175	229.2	10.6**	+7.455
Standard deviation	2.186	55.9	2.03	2.64
Range	0.5-7.4	103-315	8-15.2	+4/+11.5
95% C.I.	1.79-4.56	194-265	9.33-11.9	5.77-9.13

** p<0.001 (AI After vs AI Before)
A.I. = Amniotic Index
F.V. = Fluid Volume
95% C.I. = 95% Confidence Intervals

Table 3. — *Amniotic Fluid Index Variation (ΔAFI) before and after 12 amnioreduction procedures*

Statistical Parameters	A.I. Before (cm)	Extracted (ml)	A.I. After (cm)	ΔAFI (cm)
Mean	33.13	920	22.01**	–11.11
Standard deviation	12.70	695	5.77	8.80
Range	20-69	30-2620	15.5-33	–1/–33
95% C.I.	25.6-41.3	479-1362	18.1-25.2	–5.52/–16.7

** p<0.005 (AI After vs AI Before)
A.I. = Amniotic Index
A.F.. = Amniotic Fluid
95% C.I. = 95% Confidence Intervals

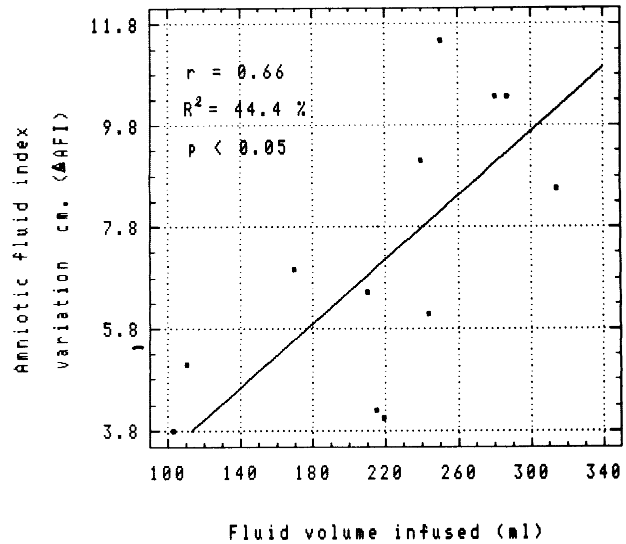

Figure 1. — Regression Analysis of Amniotic Fluid Index (ΔAFI) on fluid infused.

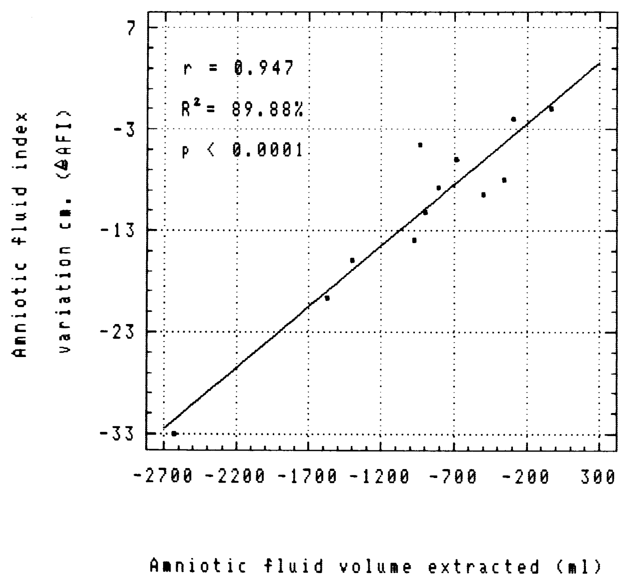

Figure 2. — Regression Analysis of Amniotic Fluid Index (ΔAFI) on amniotic fluid extracted.

Comment

Our data clearly show that the different patterns of AFI variations are related to the different invasive techniques used. As to amniocentesis, it appears evident that the procedure gives rise to clinically irrelevant AFI modifications which actually lie within the variability limits intrinsic to the procedure of AFI determination. Indeed, Bruner *et al.* [12] report a mean absolute value of intra-observer difference of 1.9 cm and an inter-observer difference of 2.9 cm; in our experience amniocentesis induced a mean AFI variation of –1.08 cm, a value which falls well within the intra-observer and inter-observer variability. In addition, the inability on our part to correlate the volume of AF extracted to ΔAFI confirms the data of Cacciatore *et al.* [13] who, despite having shown a significant post procedure AFI variation, found it impossible to make a direct correlation between the two parameters. These authors hypothesize that this situation could be attributed to the narrow range of values considered, or in other words to the minute quantity of fluid extracted and to the consequently slight variation in AFI.

Table 4. — *Relationship between the variables (Fluid Infused, Amniotic Fluid Index before procedures, Gestational Age) and ΔAFI analysed by multiple regression*

Independent Variable	Coefficient	Standard error	Z-value	Significance Level (p)
Constant	5.653	3.927	1.439	0.188
Fluid infused (ml)	0.023	0.011	1.960	0.085
AFI before (cm)	–0.390	0.370	–1.053	0.322
Gestational Age (days)	–0.012	0.018	–0.671	0.520

Table 5. — *Relationship between the variables (Fluid Extracted, Amniotic Fluid, Index before procedures, Gestational Age) and ΔAFI analysed by multiple regression*

Independent Variable	Coefficient	Standard error	Z-value	Significance Level (p)
Constant	0.359	4.858	0.07	0.942
Fluid extracted (ml)	0.006	0.002	2.530	0.035
AFI before (cm)	–0.329	0.127	–2.584	0.032
Gestational Age (days)	0.025	0.235	1.100	0.303

Sepulveda *et al.*, however, show a sufficiently significant correlation between volume of fluid infused and ΔAFI, thus demonstrating that the AFI variation is 33% dependent upon the volume infused. Our data agree with these, since in our case the ΔAFI is 44.44% dependent on the quantity of fluid infused. This agreement of results exists despite the presence of some differences as to procedure: firstly, the criterion for inclusion relative to oligohydramnios was AFI<3 cm. for Sepulveda, but AFI<5 cm for us; besides, among our patients, in contrast to those of the above mentioned authors, four cases were observed with gestational age later than the 28th week, but not beyond the 34th week, and three cases with premature membrane rupture (PROM). We here specify that in the cases of PROM at the time of AFI measurement immediately after amnioinfusion no significant discharge was perceived at the external genitals; this phenomenon occurring one-two hours later.

Besides, the linear and multiple regression analysis showed that the quantity of fluid infused, if considered alone, can predict the AFI variation, whereas if this variable is taken into consideration together with the other two parameters (gestational age and pre-procedure AFI) it does not contribute in any way to the ΔAFI prediction.

To our knowledge, this is the first report of a significant correlation between AFI variation and the volume of

Table 6. — *Estimates of Amniotic Fluid Index (cm) based on pre-procedure AFI (cm) and amniotic fluid volume extracted (ml). ΔAFI = 4.968 + 0.007 (AF volume extracted) –0.271 (pre-procedure AFI). Mean 95% Confidence Intervals +/– 19.5% ΔAFI*

AF Volume Extracted (ml)	Pre-procedure AFI (cm): 20	25	30	35	40	45	50	55	60	65	70
–500	–3.9	–5.3	–6.6	–8,0	–9.3	–10.7	–12.0	–13.0	–14.7	–16.1	–17.5
–750	–5.6	–7.0	–7.4	–9.7	–11.1	–12.6	–13.8	–14.9	–16.5	–17.9	–19.2
–1000	–7.4	–8.8	–10.1	–11.5	–12.8	–14.2	–15.5	–16.9	–18.2	–19.6	–21.0
–1250	–9.0	–10.5	–11.9	–13.2	–14.6	–15.9	–17.3	–18.7	–20.0	–21.4	–22.7
–1500	–10.9	–12.3	–13.6	–15.0	–16.3	–17.7	–19.0	–20.4	–21.7	–23.1	–24.5
–1750	–12.7	–14.0	–15.4	–16.7	–18.1	–19.4	–20.8	–22.1	–23.5	–24.9	–26.2
–2000	–14.4	–15.8	–17.1	–18.5	–19.8	–21.2	–22.5	–23.9	–25.2	–26.6	–28.0
–2250	–16.2	–17.5	–18.9	–20.2	–21.6	–22.9	–24.3	–25.7	–27.0	–28.4	–29.7
–2500	–17.9	–19.3	–20.6	–22.0	–23.3	–24.7	–26.0	–27.4	–28.7	–30.1	–31.5
–2750	-19.7	–21.0	–22.4	–23.7	–25.1	–26.4	–27.8	–29.1	–30.5	–31.9	–33.2
–3000	–21.4	–22.8	–24.1	–25.5	–26.8	–28.2	–29.5	–30.9	–32.3	–33.6	–35.0

AF extracted. From our data it emerges that the ΔAFI is 89.8% determined by the volume of AF aspirated. If we then add to this parameter the evaluation of pre-procedure AFI, ΔAFI prediction improves further; the same does not apply if we also add the evaluation of gestational age.

Thus, in particular for amnioreduction there is a strong correlation between the fluid removed and the expected ΔAFI, which allows the estimation, with considerable accuracy, as a function of a determination coefficient close to 90%, of the ΔAFI relating to the fluid removal. If we then also take into account the starting AFI, correlability improves (R^2=92%; $p<0.005$), leading to a more detailed prediction of AFI variation by means of a diagram constructed on the basis of the above mentioned data (Table 6).

We can suppose that, in relation to the quantity of fluid to be infused or removed, it is possible, particularly in the latter case, to calculate to a good degree of accuracy the consequent AFI modification. According to our data, these modifications should also be correlated to the clinical situation at the outset, that is to the pre-procedure AFI, which also determines to a great extent the quantity of fluid to be infused or extracted. The ΔAFI can vary by +/–20% if we consider the 95% Confidence Intervals for prediction. Should these results be further confirmed, the opportunity will be presented of calculating at an early stage the quantity of fluid to be infused or extracted in order to bring AFI levels back to normal.

In conclusion, we can say that the correlativity of AFI with the variation in volume induced by the various invasive procedures certainly cannot be understood as absolute; it must be evaluated case by case, in the individual clinical situation and in light of the different techniques employed.

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