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The Maternal Body Fluids and Amniotic Fluid in Near Term Pregnancies

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ABSTRACT

OBJECTIVE: This study aimed to investigate the relationship between amniotic fluid volume and mainly volume of maternal body fluid compartments and secondly maternal obesity in near term pregnancies.

STUDY DESIGN A case control study was conducted involving 211 women with near term singleton pregnancies who attended Adnan Menderes University Faculty of Medicine between 2007 and 2009. Patients in Group 1(n=119), included near term pregnancies with normal amniotic fluid index (AFI) and Group 2 included near term pregnancies complicated with idiopathic oligohydramnios (n=92). Oligohydramnios was diagnosed when AFI was measured <8 cm. For determining maternal body fluid status we used valid formulas (defined in methods). Maternal body mass index (BMI), weight gain during pregnancy and volume of maternal body fluid compartments including total body water, intracellular fluid volume, extracellular fluid volume, interstitial fluid volume, plasma volume and plasma osmolality were compared between two groups.

RESULTS: There was no significant difference between the groups in terms of maternal BMI, weight in partum, weight gain during pregnancy, volume of maternal body fluid compartments, plasma osmolality (p>0.05). Besides, there was no significant correlation with these parameters and AFI (p>0.05).

CONCLUSION: Our data favor that maternal BMI, volume of maternal body fluid compartments and plasma osmolality do not have any effect on amniotic fluid volume in near term pregnancies.

Keywords: BMI, Body fluid, Near term pregnancy, Idiopathic oligohydramnios

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Introduction

Amniotic fluid (AF) is a dynamic important component of both the health status of fetus and the mother. It is known that normal AF volume is essential for adequate intrauterine development and a better perinatal outcome.[1]

Oligohydramnios is one of known pathologies of AF. It may be associated with increased fetal and neonatal morbidity and mortality.[2] So, understanding the mechanisms that regulate AF volume is essential. The incidence of oligohydramnios in term pregnancy varies between 0.5-5% and in postterm pregnancy (>42weeks) it is observed about 15-20% of cases. Oligohydramnios is associated with increased rate of adverse pregnancy outcome.[3] In literature there have been many researches to investigate possible therapies to normalize abnormal AF volumes.[4] For example, there is a recent study claiming (there was a report claiming that) that maternal hydration have improved AF volume in oligohydramnios.[5] However, the mechanism for this effect still remains unclear. It has been suggested that improved uteroplacental perfusion or changes in maternal and fetal plasma osmolality leading to increased fetal urine flow improves AF volume. But little information exists about what is really happening in fetomaternal unite in oligohydramnios.

The researchers showed a possible link between obesity, hypertonicity and body fluid volumes.[6] However, there is only little information about relationship between Body Mass Index (BMI) and amnion fluid index (AFI) in term pregnancies. Here, we aimed to investigate relationship between AF and mainly volume of maternal body fluid compartments and secondly maternal obesity in term pregnancies.

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Material and Method

A case-control study was conducted involving randomly selected 211 women with singleton pregnancies who attended the Adnan Menderes University Hospital (Aydın, Turkey) between 2007 and 2009. Participants were divided into two groups; Group 1 including patients with normal AF at near term and Group 2 including patients with oligohydramnios at near term.

Demographic parameters like maternal age, gravity, parity, pregestational weight were interviewed in all participants. The maternal weight and height were measured, at the time of confirmation of pregnancy, in the first 10 weeks of gestation. Maternal weight at delivery were measured and weight gain during pregnancy were calculated. The body mass index (BMI) values which is defined as the weight in kilograms divided by the square of the height in meters (kg/m^2) were calculated.[7] BMI of patients at partum were determined and "obesity" was defined as BMI ≥30.[8]

For determining maternal body fluid status we used valid formulas. In a large study of adults of all ages and both sexes, amount of body water fraction according to weight, was found to be 48 ±6% for females and 58 ± 8% for males.[9] We used that percentages based on weight, to calculate body water fraction. Body water is divided into the following compartments: Intracellular fluid (2/3 of body water), extracellular fluid (1/3 of body water) and interstitial fluid (4/5 of extracellular fluid).[10] In the present study, maternal total body water, plasma volume, interstitial fluid volume, intracellular fluid volume, extracellular fluid volume was calculated. Besides, total body water per square of body surface area was determined. Do bouis formula ($BSA=(W^{0.425} \times H^{0.725}) \times 0.007184$) was used to calculate body surface area. Plasma volume was calculated by formula (1-hemotocrit) x total blood volume, plasma osmolality was all determined by formula of 2 [Na+] + [Glucose]/18 +[BUN]/2.8]/2.8 where [Glucose] and [BUN] are measured in mg/dL.[9]

An ultrasound procedure used to assess the amount of AF. To determine the AFI uterus divided into four quadrants, measuring the deepest pool free of fetal structures in each and calculating the sum of four measurements.[11] All measurements were performed by the same operator to reduce intra-observer variability, via Aloka alfa-10 ultrasound device (Hitachi Aloka Medikal Ltd., Tokyo, Japan), with 5-MHz transabdominal probe with medium transducer pressure. The mean of three repeated measurements performed by the same examiner. In term pregnancy, AFI between 8-25 cm in four quadrant measurement were accepted as normal AFI. Severe oligohydramnios was diagnosed when the AFI was measured less than 5 cm.[12] A borderline oligohydramnios was diagnosed when AFI was measured between 5-8 cm and generally no intervention is required and the perinatal outcome is generally good.[13] All fetuses having borderline oligohydramnios were monitored by using the modified biophysical profile including nonstress test monitoring combined with AFI measurement.[14]

In this study premature membrane rupture, maternal or fetal diseases like pregnancy-induced hypertension and pregestational hypertension, intrauterine growth restriction, gestational and pregestational diabetes, and all systemic diseases (nephropathy, cardiopathy, hepatopathy, and inappropriate antidiuretic hormone hypersecretion syndrome) were excluded. Besides, fetus with congenital malformations, nonreassuring nonstress test results, an altered fetal biophysical profile were not included in the study.

Neonatal outcomes including, fetal birth weights, Apgar scores 1 and 5 min after birth were compared between two groups. Neonatal outcome was defined as overall perinatal mortality from 20 weeks of gestation to 28 days of postnatal period.

Data were processed with SPSS 18.0 statistical processor software. For the numeric variables that were normally distributed, comparison between two groups was made by independent sample t test and descriptive statistics are presented as mean±standard deviation. For the numeric variables that were not normally distributed, comparison between two groups was made by Mann-Whitney U test and descriptive statistics are presented as median (25-75 percentiles). To analyze the categorical data, a chi-square test was used and descriptive statistics are presented as frequency (%). Spearman correlation was used for qualitative data and Pearson correlation for quantitative data. Level of significance of $p < 0.05$ was considered in all analyses.

Results

Demographic characteristics of patients were presented in Table 1. There was no statistically significant difference between the groups in term of maternal BMI, weight, pregestational weight and weight gain during pregnancy ($p > 0.05$).

Table 1: Demographic characteristics of participants

	Control (Group 1) n=92	Oligohydramnios (Group 2) n=119	p
Age (years)	28.26±5.03	29.17±5.59	0.214
Gravity (n)	2.34±1.94	2.13±1.27	0.363
Parity (n)	1.01±1.49	0.80±0.90	0.251
Gestational Age (weeks)	38.19±1.63	37.81±1.77	0.108
BMI (kg/m^2)*	30.01±5.32	29.12±4.31	0.192
Weight (kg)	76.80±14.01	75.14±11.60	0.359
Pregestational weight (kg)	62.85±13.66	62.04±11.81	0.651
Weight gain in pregnancy (kg)	13.58±5.20	13.15±5.29	0.554

**BMI: Body Mass Index, Statistical significance: p<0.05*

Comparison of maternal body fluid compositions of Group 1 and 2 was presented in Table 2. In Group 2, 88 (74%) patients had severe oligohydramnios (AFI < 5cm) and 31 (26%) patients had borderline oligohydramnios (AFI >5 and <8 cm). The maternal plasma volume, plasma osmolality, total body water, intracellular fluid volume, extracellular fluid volume and interstitial fluid volume showed no significant difference in the Groups 1 and 2 (p>0.05). The variables were comparable in patients with severe and borderline oligohydramnios (p>0.05). Besides total body water per square of body surface area was not different between groups (p>0.05) (Table 2).

The calculated correlations of AFI with maternal variables in all participants were presented in Table 3. There was no correlation between BMI and AFI (r=0.54, p=0.437). The AFI between the patients with BMI <30 kg/m^2 and BMI ≥30 kg/m^2 showed no significant difference (p>0.05). Besides there was no correlation between AFI and pregestational weight, weight gain during pregnancy, the maternal plasma volume, plasma osmolality, total body water, intracellular fluid volume, extracellular fluid volume and interstitial fluid volume (p>0.05). AFI was only inversely correlated with gestational age (r=-0.199, p=0.03).

Among 47 (53.4%) of 88 patients having AFI< 5cm, had BMI was found to be ranging between 25-29.9 kg/m^2. However, among the patients having BMI<25 kg/m^2, 11(42.3%) patients had AFI >8cm, 5(19.23%) patients had 5-8 cm, 10 (38.46%) patients had AFI< 5cm. That showed that having BMI <30 kg/m^2 was not correlated with having severe oligohydramnios.

The birth weights of babies were lower in patients with oligohydramnios (p<0.01). However, Apgar scores at 1 and 5 min after birth were comparable between two groups (p>0.05) (Table 4).

Table 2: Comparison of maternal body fluid composition of participants

	Control group (Group 1) n=92	Patients with oligohydramnios (Group 2) n=119	p
Maternal plasma volume (L)	3.20±0.58	3.13±0.48	0.375
Total body water (L)	38.50±7.03	37.59±5.80	0.318
Intracellular fluid volume (L)	25.67±4.68	25.03±3.86	0.293
Extracellular fluid volume (L)	12.82±2.34	12.52±1.93	0.320
Interstitial fluid volume (L)	9.61±1.75	10.91±10.53	0.191
Plasma osmolality (mOsm/kg)	278.39±14.44	278.42±13.18	0.986
Total body water /m^2(L/m^2)	21.31±2.06	20.93±1.85	0.159

L: Liter, mOsm/kg: Miliosmole/kilogram, Statistical significance: p<0.05

Table 3: Correlation of amniotic fluid index with maternal variables

	All participants (n=219)		Patients with oligohydramniosis (n=92)	
	r	p	r	p
BMI (kg/m^2)*	0.091	0.190	0.019	0.838
Weight at partum (kg)	0.065	0.348	0.034	0.714
Pregestational weight (kg)	0.033	0.635	0.033	0.723
Weight gain in pregnancy (kg)	0.046	0.511	-0.027	0.767
Gestational Age (weeks)	0.039	0.578	-0.199	0.03
Maternal plasma volume (L)	0.060	0.389	0.025	0.784
Total body water (L)	0.063	0.359	0.018	0.844
Intracellular fluid volume (L)	0.064	0.355	0.006	0.945
Extracellular fluid volume (L)	0.063	0.361	0.018	0.847
Interstitial fluid volume (L)	-0.074	0.284	-0.005	0.956
Plasma osmolality (mOsm/kg)	-0.037	0.597	-.0.124	0.178
Total body water /m^2(L/m^2)	0.068	0.329	0.008	0.929

**BMI: Body Mass Index, L: Liter, mOsm/kg: Miliosmole/kilogram, Statistical significance: p<0.05*

Table 4: Obstetric parameters in patients with oligohydramniosis and control group

	Control (Group 1) n=92	Patients with oligohydramniosis (Group 2) n=119	P
Birth Weight	3289.83±513.65	2850.12±586.96	<0.01
Apgar score1 min after birth	8.82±0.56	8.86±0.51	0.604
Apgar score 5 min after birth	9.95±0.20	9.92±0.57	0.425

Statistical significance :p<0.05

Discussion

Obstetricians concern with decrease in AF volume in pregnancy as it may be related with adverse pregnancy outcomes. Although the researches aiming to increase AF volume by giving maternal fluid have been promising, there have been only limited data about oligohydramnios and its mechanism. It is still a debate that whether a decrease in maternal fluid volume causes a decrease in uteroplacental blood flow, and in fetal urine leading to a decrease in AF volume or this is just a reasonable, logical inference. To investigate the dilemma, we designed the present study and determined no relationship between AF volume and maternal fluid volumes and components.

In the present study, it was determined that, especially in oligohydramnios group, AFI was inversely correlated with gestational age. Similarly, in literature, it is known that incidence of oligohydramnios is increased in post-term pregnancies.[15] But, present knowledge about pathophysiology of idiopathic oligohydramnios is incomplete. It is determined that any pathology in the formation and reabsorption of AF may cause oligohydramnios.[15] So, first issue about AF volume is placental permeability. Placental trophoblast membrane permeability increases with gestational ages in human. So, in late gestation the increased water flow is necessary. However, average AF volume increases progressively from approximately 20 mL at 10 weeks to 630 mL at 22 weeks and 770 mL at 28 weeks gestation.[16] There is only little change in AF volume between 29 and 37 weeks. Beyond 39 weeks, AF volume decreases sharply and about 515 mL AF volume is determined at 41 weeks. So, there is a nearly 33% decline in AF volume per week.[17] In the 42nd week the incidence is estimated about 15-20%.[3] So there should be a mechanism other than placental trophoblast membrane permeability in idiopathic oligohydramnios.

On the other hand, it is suspected that other mechanisms such as volumes of body fluid compartments and changes in maternal plasma osmolality probably were claimed to play an important role in determining AF volume[18] other than placental trophoblast membrane permeability. In a large study including all ages and both sexes, it is shown that water constitutes ~53% of the adult human body. However, it is known that this ratio varies substantially by age, sex, and amount of fat in body composition. Plasma volume is important for estimation of a patient's body fluid status.[19] In the literature, the common technique for determination of plasma volume is the intravenous injection of a known amount of a dye like Evans blue and the subsequent measurement of its dilution in a time period. Besides, varied substances can be used to measure different fluid compartments. For example, tritiated water or heavy water for total body water volume and inulin is used for measuring the extracellular fluid volume.[19] In the present study, we consulted with physiology department about usage of these substances but we concluded that they could not be used due to ethical problems about giving an agent to pregnant women because of their unknown risks on fetal development and health status. So, formulas based on maternal weight were used to calculate volume of fluid compartments. There was no difference in maternal body water, intracellular fluid volume, extracellular fluid volume, interstitial fluid volume and plasma volume. So, that limitation of present research may be overcomed by animal studies instead of human being, to investigate actual volume of body fluid compartments.

Lastly, in formation of AF, water transfer across the placenta may be driven by hydrostatic or osmotic forces according to Starling forces. Therefore, changes in these forces may be associated with changes in fetal water and so in AF volume. In present study, there was no difference in plasma osmolality in Group 1 and 2. In harmony with results of our study, it was determined AFI was not associated with either plasma osmolality, in a study about correlation of AFI with maternal plasma volume and composition in normal pregnancy.[20] Osmolality changes for placental water flow could not be measured. However gross changes in maternal osmolality can be determined. It is known that there is a diurnal variation in maternal plasma osmolality, in normal gestation. Placenta can buffer these small variations and these variations in osmolality are not associated with changes in AF volume. However, it was claimed that, pathologic alterations in maternal osmolality have been shown to affect AF volume.[21] In literature, there have been many researches investigating therapies to normalize amniotic fluid. In a study, it was determined that maternal dehydration and increased maternal serum osmolality (by more than 30 mOsm/kg) may be associated with oligohydramnios [22] while a decrease in maternal osmolality (of 20 mOsm/kg) is associated with increased AF volume.[23] The controversies may be due to occurrence of these studies all animal studies and the case reports about maternal diabetes insipidus. There has been no study about plasma osmolality and AFI in pregnant women. Only we know that, oral hydration increased AFI acutely, but this change did not continue for a long time .[24]

Again, maternal BMI, weight, pregestational weight and weight gain during pregnancy in Group1 and Group 2 were similar. Obesity during pregnancy is of important concern due to its adverse effects on both fetus and the mother.[25] To the best of our knowledge, there is no study investigating impacts of maternal obesity on AFI of fetus alone. Only in one paper, while reporting results of study, it was claimed that underweight mothers showed an increased risk of oligohydramnios and small for gestational age fetuses. In that paper, increased risk of oligohydramnios in underweight mothers was not associated with any other fetal condition. However, this finding has not been described in any paper in the literature, yet.[26] So result of the present study on the effect of maternal obesity on AFI should be confirmed by large, multicentered including high number of cases.

In conclusion, the maternal hydrostatic forces might have more great impact on AF, than maternal body fluid volume and plasma osmolality. In the literature, there is only little evidence that clinical alterations in maternal hydrostatic forces affecting placental water flux. Ex vivo studies of perfused human placental lobules suggested that vasoactive substances in the fetal circulation might increase fetal venous pressure and induce loss of fluid to the maternal circulation.[27] This data claimed that fetal stress had a role in production of these vasoactive substances and could induce fetal to maternal fluid loss and therefore oligohydramnios through a hydrostatic mechanism.[15] Supporting that fetal stress and production of vasoactive substances theory, we have determined that biometric measures of fetuses and birth weight of babies were lower in patients with oligohydramnios. But which is the start point in vicious circle about fetal stress causing synthesis of vasoactive substances and inducing oligohydramnios is still a mystery. However this issue is complex and controversies should be clarified by cellular human physiological studies at fetomaternal circulation explaining mechanism of maternal stress and hydrostatic forces in pathophysiology of idiopathic oligohydramnios.

Terme Yakın Gebeliklerde Amniyon Sıvısı Miktarı ve Maternal Vücut Sıvıları

ÖZET

AMAÇ: Bu çalışmanın amacı, terme yakın gebeliklerde, amniyon sıvı miktarı ile maternal vücut sıvı kompartman hacimleri ve maternal obezite arasındaki ilişkinin araştırılmasıdır.

GEREÇ VE YÖNTEM: Bu vaka kontrol çalışması, 2007-2009 yılları arasında Adnan Menderes Üniversitesi Tıp Fakültesi'ne başvuran, terme yakın tekil gebeliğe sahip 211 hastada yapılmıştır. Grup1 (n=119) normal amniyon sıvı indeksine (AFI) sahip, terme yakın hastaları, Grup 2 (n=92) ise idyopatik oligohidramniosu olan terme yakın gebeleri içermektedir. Amniyon sıvı indeksi <8cm ölçüldüğünde, oligohidramnios olarak tanımlandı. Maternal vücut sıvı kompartman hacim ölçümleri geçerli formüller ile hesaplandı. Gruplar arasında, maternal vücut kitle indeksi (VKİ), gebelik sırasında alınan kilo, maternal vücut sıvı kompartman hacimleri (total vücut su hacmi, intrasellüler sıvı hacmi, ekstrasellüler sıvı hacmi, interstisyel sıvı hacmi, plazma hacmi) ile plazma ozmalalitesi karşılaştırıldı.

BULGULAR: Gruplar arasında maternal VKİ, gebelikteki kilo alımı, doğum sırasındaki kilo, maternal vücut sıvısı kompartman hacimleri ve plazma ozmalalitesi açısından fark saptanmadı (p>0.05). Ayrıca, bu parametreler ile amniyon sıvı indeksi arasında herhangi bir korelasyon gözlenmedi (p>0.05).

SONUÇ: Datamız, maternal VKİ, maternal vücut sıvı kompartman hacimleri ve plazma ozmalalitesinin, terme yakın gebelerde amniyon sıvı hacmi üzerine herhangi bir etkisinin olmadığını göstermektedir.

Anahtar Kelimeler: VKİ, Maternal vücut sıvısı, Terme yakın gebelik, İdyopatik oligohidramnios

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