DOI: 10.7860/IJARS/2016/17869.2166

Original Article

Radiology Section

The Relationship Between Fetal Crown-Rump Length in the Early First Trimester and Growth Parameters at Birth

SHEIDA SHABANIAN, MAHSA HAJIRAHIMI, FOROUZAN GANJI, ABOLFAZL KHOSHDEL, MAHDOKHT HAJIRAHIMI, MORTEZA SEDEHI

ABSTRACT

Introduction: Crown–rump length (CRL) has been demonstrated to be an accurate predictor of birth growth and can cause many complications.

Aim: This study was conducted to determine the association between CRL in the first trimester and weight, length and Head circumference (HC) at birth.

Materials and Methods: This was a prospective, cohort study in Hajar Hospital of Shahrekord, southwest Iran from March, 2013 to June, 2014 (within 15 months). Thirty women achieving pregnancy with intrauterine insemination and in vitro fertilization were compared with 60 women getting pregnant naturally. Between the days 59 and 83 after insemination, fetal CRL was examined by ultrasound. Then, the patients were followed up and weight, length and HC at birth were recorded. The data were analyzed by SPSS 22.

Results: There was a direct correlation between CRL and length in the studied infants (0.91, $p<0.001$). The correlation between CRL and length was derived significant in both the infants born after artificial insemination (AI) and born naturally (0.69 and 0.7 respectively, $p<0.001$). There was a direct correlation between CRL and HC (0.27, $p=0.01$) in AI and naturally born groups (0.47 and 0.26 respectively, $p<0.05$). There also was a significant, direct correlation between CRL and weight (0.69, $p=0.001$) in both AI and naturally born groups (0.53 and 0.78 respectively).

Conclusion: CRL in the first trimester is significantly correlated with weight, length and HC at birth and can be used in screening. However, this index, as a diagnostic test, cannot exactly predict real length, HC and weight at birth.

Keywords: Biometrics, Infant, Ultrasound

INTRODUCTION

Fetal growth restriction could lead to metabolic disorders in the infants, impaired functioning in children and chronic diseases in adults [1]. The weight, length and head circumference (HC) of infants are measured at birth because of their clinical significance [2]. The fetal age can be estimated through measurement of head, abdominal and femoral circumference [3]. Crown–rump length (CRL) has been already demonstrated to be an accurate predictor of birth growth and can be easily measured (by enlarging the image to life size and detecting the embryonic echo within the gestational sac on the longitudinal scan) [4]. Ultrasound in the first trimester can be used for definite pregnancy, failure including the infants with CRL of at least 7 mm [5], and diagnosing other defects in central nervous system, neck, spine and heart [3]. Fetal growth impairment begins in the first trimester and could result in adverse pregnancy outcomes [6].

Significant discordance in CRL is associated with higher risk of adverse perinatal outcomes including fetal loss, weight discordance, fetal anomalies, preterm delivery and even perinatal death [7-11]. Studies have demonstrated that the CRL in the first trimester can predict whether the fetus is large or small for gestational age [12,13].

A study demonstrated a correlation between first-trimester CRL and birth weight. Further, the use of CRL cut-off value in predicting low birth weight remains to be confirmed [14]. Variations in CRL measurement may greatly affect the risk assessment of chromosomal anomalies within the first trimester [15,16].

In a study in Shiraz, South Iran a smaller-than-expected CRL in the first trimester had association with neonatal low birth weight, adverse pregnancy outcomes, and associated relative risk. The difference between expected and observed CRL was significantly associated with low birth weight, abortion and pregnancy emergency termination [17]. The

birth weight in in vitro fertilization (IVF) is not correlated with CRL discrepancy. In addition, IVF pregnancies may not be biologically similar to spontaneous conceptions [18,19].

Since, the time of egg fertilization in the infertile women with intrauterine insemination (IUI) and IVF-assisted conception is more specific than the women with natural pregnancy, then the CRL is likely to be measured more precisely within the first trimester and its association with fetal biometric factors at birth might be clearer in such women than those with natural pregnancy. Moreover, the association between fetal indices and birth weight has been consistently examined. However, the aim of the present study is to investigate the association between these indices, and length and HC in infants, so that we will be able to take necessary actions to prevent delivery of the infants with low birth weight and/or HC.

MATERIALS AND METHODS

The present prospective, cohort study was conducted on the patients admitted to the Gynecology Clinic of Hajar Hospital in Shahrekord, Southwest Iran from March, 2013 to June, 2014 (for 15 months). The ultrasound was performed on the participants by a gynecologist in this clinic. Target group consisted of the women achieving pregnancy by IVF and IUI, and the other group consisted of the women achieving pregnancy naturally. The sample size was calculated 30 for each group according to sample size formula.

The women with the age of 16 years and over, living singleton fetus, the gestational age between 10 weeks and 3 days and 13 weeks and 6 days according to the CRL and consent to participate in the study were enrolled and the exclusion criteria were any fetal anomalies.

Because of the inconsistency and uncertainty of the previous findings on the association between CRL and birth weight which was mainly due to the use of menstruation date to estimate the day at conception, the present study examined the women inseminated through IVF and IUI to determine the exact day at conception. These women were those admitted to the gynecology clinic for infertility-related problems and were candidate for these two methods. Because the findings on this specific group cannot be conveniently generalized to whole community, a group of women with natural pregnancy was enrolled into the study to compare the data on the two groups.

After the research protocol was explained completely for the parents, if they were consent, they were asked to fill out and sign the consent form of enrollment into the study. Then, between the days 59 to 83 after insemination, CRL of fetuses was determined by ultrasound. Measuring CRL is the most accurate method of determining gestational age prior to the week 14. Ultrasound was done in a single center (Hajar Hospital, Shahrekord), by a sonographer (project executor) and with a single device. Then, the patients were followed up and the weight, length and HC at birth were measured after delivery. The data in this study were analyzed by SPSS 22 using chi-square, 't'-test, paired 't'-test and Mann-Whitney.

RESULTS

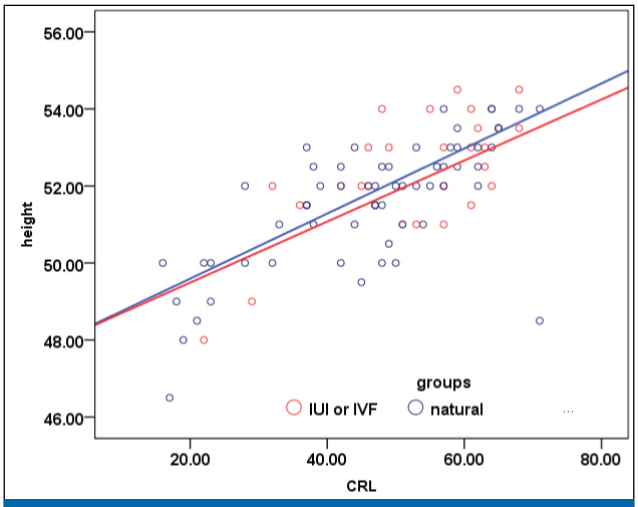
In this study, 30 infants fertilized by IVF and IUI were compared with 60 infants fertilized naturally. [Table/Fig-1] shows the mean (standard deviation) of neonatal anthropometric parameters of the two groups. The mean CRL in the first trimester in artificially inseminated (AI) and naturally fertilized (NF) groups was 52 ± 12 and 46.5 ± 14.6 cm respectively, with no significant difference (p=0.08) according to 't'-test. The mean length in AI and NF groups was 52.3 ± 1.47 and 51.59 ± 1.65 cm respectively, with no significant difference (p=0.05) according to 't'-test. The mean HC in AI and NF groups was 33.23 ± 0.94 and 33.61 ± 1.39 cm respectively, with no significant difference (p=0.19) according to 't'-test. Finally, the mean weight in AI and NF groups was 3240 ± 250.3 and 3281.2 ± 299.6 grams respectively, with no significant difference (p=0.52).

A correlation (0.91) was observed between the CRL and length at birth, which was significant (p<0.001) by Pearson correlation coefficient. The correlation between CRL and length was derived significant in both AI and NF groups (0.69 and 0.7 respectively, p<0.001) [Table/Fig-1]. [Table/Fig-2] illustrates the correlation between CRL and length in the infants of the two groups.

There was a direct correlation between CRL and HC at birth

Group	All infants	Artificial insemination	Natural fertilization
Correlation value	0.71	0.69	0.7
p-value	<0.001	<0.001	<0.001

[Table/Fig-1]: Correlation between crown–rump length and length at birth in all infants, the infants fertilized naturally and the infants inseminated artificially.



[Table/Fig-2]: The correlation between crown-rump length and length in the infants fertilized naturally and the infants inseminated artificially.

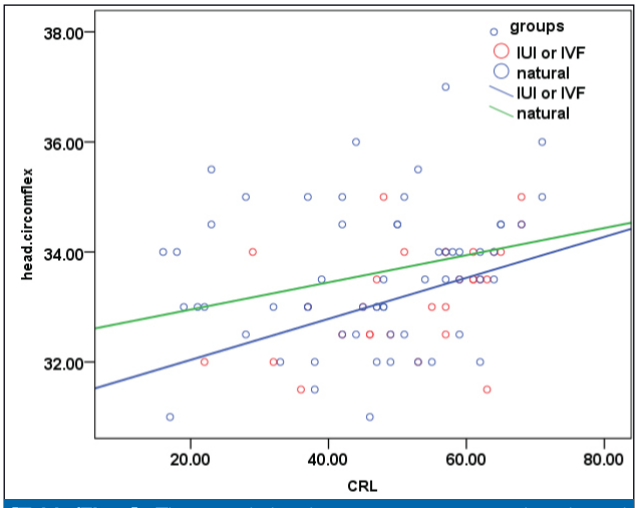
(0.27, p=0.01) which was significant by Pearson test. This correlation was derived 0.47 and 0.26 in AI and NF groups respectively, which was significant (p<0.05) for both groups by Pearson test [Table/Fig-3]. [Table/Fig-4] illustrates the correlation between CRL and HC in the infants of the two groups.

In all studied infants, there was a direct correlation between CRL and birth weight (0.69) which was significant (p=0.001) by Pearson correlation coefficient. This correlation was derived 0.53 and 0.78 in AI and NF groups, respectively, which was significant (p<0.05) for both groups by Pearson correlation coefficient [Table/Fig-5]. [Table/Fig-6] illustrates the correlation between CRL and birth weight in the infants of the two groups.

The highest correlation in AI group was obtained between CRL and length, but in NF group between CRL and weight, with no significant difference (p=0.14) between the two groups. [Table/Fig-7] illustrates the correlation between CRL and length, HC and weight at birth in the infants.

Group	All infants	Artificial insemination	Natural fertilization
Correlation value	0.47	0.27	0.26
p-value	<0.008	<0.01	<0.04

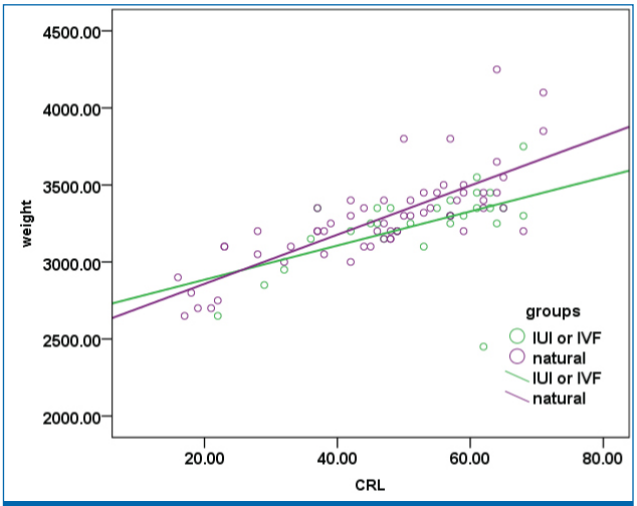
[Table/Fig-3]: Correlation between crown–rump length and head circumference at birth in all infants, the infants fertilized naturally and the infants inseminated artificially.



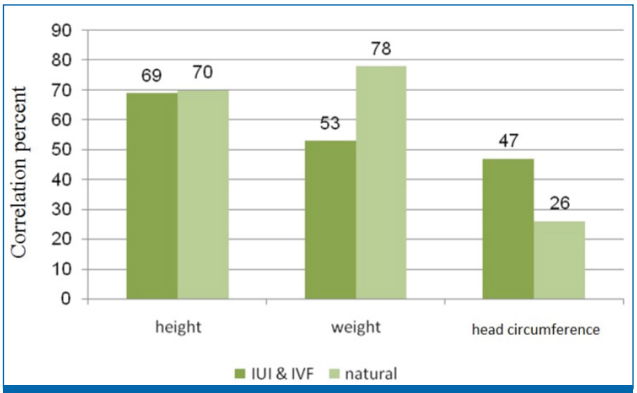
[Table/Fig-4]: The correlation between crown-rump length and head circumference in the infants fertilized naturally and the infants inseminated artificially.

Group	All infants	Artificial insemination	Natural fertilization
Correlation value	0.53	0.69	0.78
p-value	0.003	<0.001	<0.001

[Table/Fig-5]: Correlation between crown-rump length and birth weight in all infants, the infants fertilized naturally and the infants inseminated artificially.



[Table/Fig-6]: The correlation between crown-rump length and birth weight in the infants fertilized naturally and the infants inseminated artificially.



[Table/Fig-7]: The correlation between crown-rump length, and length, Head circumference and weight at birth in the infants fertilized naturally and the infants inseminated artificially.

Variable	β value	p-value	Overestimated		Underestimated	
			%	No.	%	No.
Length	0.71	<0.001	40	44.4	50	55.6
Head circumference	0.27	0.01	48	53.3	42	46.7
Weight	0.69	<0.001	48	53.3	42	46.7

[Table/Fig-8]: Anthropometric indices for crown–rump length.

Linear regression of the above data indicated that, per one-unit increase in CRL, length increased by 0.71 and the association was statistically significant (p<0.001), but analysis of the residuals (difference between actual and estimated weight and length by regression analysis) showed that, CRL was not a suitable variable for assessing the fetal length, such that the length was underestimated in 40 (44.4%) cases and overestimated in 50 (55.6%) cases and no difference was observed between the actual and estimated values..

According to the linear regression, per one-unit increase in CRL, HC varied by 0.27 and the association was statistically

significant (p<0.01). Analysis of the residuals showed that, HC was underestimated in 48 (53.3%) cases and overestimated in 42 (46.7%) cases and there was no case of matching between the actual and estimated values.

Based on the findings of linear regression, per one-unit increase in CRL, the birth weight increased by 0.69 and the association was statistically significant (p<0.001), but analysis of the residuals showed that, CRL was not a suitable variable for assessing the birth weight, such that the weight was underestimated in 48 cases (53.3%) and overestimated in 42 cases (46.7%) and there was no matching between the actual and estimated values [Table/Fig-8].

DISCUSSION

The purpose of the present study was to determine the relationship between fetal CRL in the early first trimester and growth parameters at birth in the first trimester. Based on the findings of the present study, there was a significant, direct correlation between CRL, and length, HC and weight at birth for both the babies born naturally and those born after AI. Therefore, it is inferred that CRL may be a suitable, reliable index of fetal growth and development. In this regard, ultrasound can be used in early pregnancy for understanding fetal development. In Vafaei et al., study, consistent measurement of CRL during the first trimester to detect CRLs shorter than those expected for gestational age was useful to prevent adverse pregnancy outcome [17]. The findings of some studies in other regions worldwide have indicated that, CRL could also be an accurate predictor of birth weight. CRL has been an appropriate index to predict the birth weight with high sensitivity and specificity [9,14, 17, 20, 21]. In a study that was performed to investigate the relationship between CRL (using ultrasound scan in which CRL was measured) and birth weight, length and HC of the newborn, birth HC and length of infants were higher in the group with larger-than-expected CRL than the groups with smaller-than-expected and normal CRL [22].

In contrast to this study, in Ben-Ami et al., study, there was no significant correlation between CRL discrepancy and birth weight discordance in both IVF and fertility treatment-conceived pregnancies [18]. The reason for inconsistency of the findings between our study and other studies could be attributed to determining the precise gestational age per the time of IUI or IVF in Ben-Ami et al., study [18].

As the results in present study indicated, the mean CRL in the first trimester in AI and NF groups was 52 ± 12 and 46.5 ± 14.6 cm, respectively. According to our study findings, although there was a significant association between the CRL and fetal anthropometric indices at birth, according to the regression analysis, the estimated values were not close to the actual values and hence satisfactorily stable, such that the variables were underestimated in approximately half of the infants and overestimated in the rest.

The advantage of our study is that the date of ovulation in the women with IVF was documented exactly. Most studies have calculated gestational age by menstrual history by which the timing of ovulation cannot be evaluated precisely. Besides that, we used transabdominal ultrasonography. But, a study has shown that transvaginal sonography in early pregnancy is superior for early first trimester pregnancy structure [23]. However, another study showed that transabdominal sonography was comparable to transvaginal sonography with regard to the evaluation of gestational age if CRL is measured after six weeks [24].

LIMITATION

Despite matching the groups for socioeconomic status and other variables, different genetic predispositions and diet in the participants could affect the infants, biometrics. Further, as the duration of study was long, we had difficulty following up the women with IVF and IUI and therefore their number was half of the number of the women with natural pregnancy.

CONCLUSION

CRL in the first trimester is associated with growth parameters at birth, and can be used for screening. However, this index cannot be used to exactly determine real length, HC and weight at birth. Therefore, when CRL represents abnormal weight, length and HC in the infants, other diagnostic methods should be used to determine the real fetal growth or the pregnant women should undergo intensive care. Hence, CRL could be used for screening purposes rather than as a diagnostic test. Ultrasound can be used in early pregnancy for understanding fetal development even in AI women. The results of this study could be used by pediatricians and considered in future studies so as to enable obstetricians to manage prenatal care and delivery more efficiently.

ACKNOWLEDGMENT

This work was obtained from a thesis approved at Shahrekord University of Medical Sciences, Shahrekord, Iran (grant no. 1143). The authors gratefully thank the women who participated in the study.

REFERENCES

[1] Kramer MS, Platt R, Yang H, McNamara H, Usher RH. Are all growth-restricted newborns created equal(ly)? *Pediatrics*. 1999;103(3):599-602.
[2] McIntire DD, Bloom SL, Casey BM, Leveno KJ. Birth weight in relation to morbidity and mortality among newborn infants. *N Engl J Med*. 1999;340(16):1234-38.
[3] Sreeramareddy CT, Chuni N, Patil R, Singh D, Shakya B. Anthropometric surrogates to identify low birth weight Nepalese newborns: a hospital-based study. *BMC Pediatr*. 2008;8:16.

[4] Kurjak A, Cecuk S, Breyer B. Prediction of maturity in first trimester of pregnancy by ultrasonic measurement of fetal crown-rump length. *J Clin Ultrasound*. 1976 ;4(2):83-84.
[5] Doubilet PM. Ultrasound evaluation of the first trimester. *Radiol Clin North Am*. 2014 ;52(6):1191-99.
[6] Gardosi J, Francis A. Early pregnancy predictors of preterm birth: the role of a prolonged menstruation-conception interval. *BJOG.* 2000;107(2):228-37.
[7] Palmer K, Delpachitra P, Onwude J, Rombauts L, Meagher S, Tong S. Association between twin discordance at 6-9 weeks' of gestation and birthweight complications. *Twin Res Hum Genet*. 2010 ;13(4):389-92.
[8] Shahshahan Z, Hashemi M. Crown-rump length discordance in twins in the first trimester and its correlation with perinatal complications. *J Res Med Sci*. 2011;16(9):1224-27.
[9] Johansen ML, Oldenburg A, Rosthoj S, Cohn Maxild J, Rode L, Tabor A. Crown-rump length discordance in the first trimester: a predictor of adverse outcome in twin pregnancies? *Ultrasound Obstet Gynecol*. 2014 ;43(3):277-83.
[10] Harper LM, Roehl KA, Odibo AO, Cahill AG. First-trimester growth discordance and adverse pregnancy outcome in dichorionic twins. *Ultrasound Obstet Gynecol*. 2013 ;41(6):627-31.
[11] Miller J, Chauhan SP, Abuhamad AZ. Discordant twins: diagnosis, evaluation and management. *Am J Obstet Gynecol*. 2012 ;206(1):10-20.
[12] Pardo J, Peled Y, Yogev Y, Melamed N, Ben-Haroush A. Association of crown-rump length at 11 to 14 weeks' gestation and risk of a large-for-gestational-age neonate. *J Ultrasound Med*. 2010;29(9):1315-19.
[13] Thorsell M, Kaijser M, Almstrom H, Andolf E. Large fetal size in early pregnancy associated with macrosomia. *Ultrasound Obstet Gynecol*. 2010;35(4):390-94.
[14] Kang JY, Park EJ, Yang YS, Park M, Park WI. Crown-rump length measured in the early first trimester as a predictor of low birth weight. *Yonsei Med J*. 2013 ;54(4):1049-52.
[15] Salomon LJ, Bernard M, Amarsy R, Bernard JP, Ville Y. The impact of crown-rump length measurement error on combined Down syndrome screening: a simulation study. *Ultrasound Obstet Gynecol*. 2009;33(5):506-11.
[16] Kagan KO, Hoopmann M, Baker A, Huebner M, Abele H, Wright D. Impact of bias in crown-rump length measurement at first-trimester screening for trisomy 21. *Ultrasound Obstet Gynecol*. 2012;40(2):135-39.
[17] Vafaei H, Samsami A, Zolghadri J, Hosseini-Nohadani A. Correlation of first-trimester fetal crown-rump length with outcome of pregnancy and birth weight. *Int J Gynaecol Obstet*. 2012;119(2):141-44.
[18] Ben-Ami I, Sheena L, Svirsky R, Odeh M, Rosen H, Melcer Y, et al. The association of crown-rump length discrepancy with birthweight discordance in spontaneous versus assisted conception dichorionic twins. *Prenat Diagn*. 2014;34(8):748-52.
[19] Hansen M, Bower C, Milne E, de Klerk N, Kurinczuk JJ. Assisted reproductive technologies and the risk of birth defects-A systematic review. *Hum Reprod.* 2005;20(2):328-38.
[20] Taksande A, Vilhekar KY, Chaturvedi P, Gupta S, Deshmukh P. Predictor of low birth weight babies by anthropometry. *J Trop Pediatr.* 2007;53(6):420-23.
[21] Mullany LC, Darmstadt GL, Khatry SK, Leclerq SC, Tielsch JM. Relationship between the surrogate anthropometric measures, foot length and chest circumference and birth weight among newborns of Sarlahi, Nepal. *Eur J Clin Nutr*. 2007;61(1):40-46.
[22] Ustunyurt E, Simsek H, Korkmaz B, Iskender C. First-trimester crown-rump length affects birth size symmetrically. *J Matern Fetal Neonatal Med*. 2014 ;11:01-04.
[23] Coleman BG, Arger PH, Grumbach K, Menard M, Mintz MC, Allen KS, et al.Transvaginal and transabdominal sonography: prospective comparison. *Radiology*. 1988;168(3):639-43.
[24] Lohr PA, Reeves MF, Creinin MD. A comparison of transabdominal and transvaginal ultrasonography for determination of gestational age and clinical outcomes in women undergoing early medical abortion. *Contraception*. 2010;81(3):240-44.

AUTHOR(S):

1. Dr. Sheida Shabanian
2. Dr. Mahsa Hajirahimi
3. Dr. Forouzan Ganji
4. Dr. Abolfazl Khoshdel
5. Dr. Mahdokht Hajirahimi
6. Dr. Morteza Sedehi

PARTICULARS OF CONTRIBUTORS:

1. Assistant Professor, Department of Obstetrics and Gynecology, Shahrekord University of Medical Sciences, Shahrekord, Iran.
2. Deputy of Health, Jundishapur University of Medical Sciences, Baghmalek, Ahwaz, Iran.
3. Assistant Professor, Department of Community Medicine, Shahrekord University of Medical Sciences, Shahrekord, Iran.
4. Associate Professor, Department of Pediatrics and Clinical Biochemistry Research Center, Shahrekord University of Medical Sciences, Shahrekord, Iran.
5. Student, Department of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran.
6. Assistant Professor, Department of Biostatistics, Shahrekord University of Medical Sciences, Shahrekord, Iran.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Mahsa Hajirahimi,
Shahid Tabatabaei Hospital, Jundishapour University of Medical Sciences, Baghmalek, Ahwaz, Iran.
E-mail: dr.hajirahimi@gmail.com

FINANCIAL OR OTHER COMPETING INTERESTS:
None.

Date of Publishing: **Jul 01, 2016**