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Umbilical cord twist – Does it play a role in placental morphology?

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SUMMARY

Studies have described the placental morphology and its changes in a pathological scenario. But the role of a twisting pattern of umbilical vessels in determining the placental morphology of uncomplicated pregnancy has not been discussed. The objective of the study was to determine the clinical significance of umbilical cord twist in determining the umbilical cord coiling index, the diameter of hyrtl's anastomosis, branching pattern of the placental vasculature, placental weight, Eccentricity index and Cord centrality index. The proportion of umbilical cords with left and right twist were 246 (78.6%) and 67 (21.4%) respectively. The right twisted cords had significant higher umbilical artery diameter, higher umbilical cord coiling index and preferential magistral pattern of blood vessels. This proves that twisting of the cord might play a minor role in altering the blood flow and determining the vasculature pattern but not sufficient enough to influence the placental weight, the shape of the placenta and umbilical cord insertion.

Key words: Umbilical twist – Coiling index – Hyrtl's anastomosis – Placental vasculature

INTRODUCTION

The placenta is an effective exchange organ that provides essential nutrients and gases to the developing fetus (Benirschke et al., 2012). The branches of umbilical vessels that traverse along the fetal surface of the placenta are referred to as chorionic vessels. There are two different patterns of chorionic vessels – Dispersal and Magistral. In the dispersal type, the umbilical vessels undergo successive divisions with gradually diminishing calibre towards the periphery, while in the magistral pattern the vessels traverse to the edge of the placenta without appreciable decrease in diameter of vessels (Verma et al., 2012). The placental shape varies from round to oval and is influenced by the placental vascular pattern. The umbilical cord insertion can be categorized into central, paracentral and marginal. A marginal insertion has been associated with intrauterine growth retardation (IUGR), still birth and neonatal death. In recent years, eccentricity Index (EI) and cord centrality index (CCI) are used to quantify the shape of the placenta and the centrality of umbilical cord insertion respectively (Pathak et al., 2010).

A normal umbilical cord is coiled with two umbilical arteries and one vein (right umbilical vein obliterates). The two arteries are connected by Hyrtl's anastomosis (HA) to equalize the pressure for uniform blood distribution (Ullberg et al., 2003; Gordon et al., 2007). Several theories have been proposed to explain the umbilical cord coiling including the fetal movements, differential umbilical vascular growth rates, and the arrangements of muscular fibers in the umbilical arterial wall (Edmonds et al., 1954; Lacro et al., 1987; Laat et al., 2007). Umbilical cord index (UCI) represents the number of complete coils over the length of the umbilical cord, and has been found to be an effective indicator of perinatal outcome (Chitra et al., 2012; Jessop et al., 2014).

The most distinctive feature of the umbilical cord is its chirality or helical pattern. A counter-clockwise or left-sided twist is more common than the clockwise or right-sided twist, and may be seen as early as the first trimester of pregnancy by ultrasound examination. A right sided twist is often associated with the presence of single umbilical artery, congenital malformations, and placenta previa (Qin et al., 2002; Kalish et al., 2003; Gupta et

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Fig 1. Umbilical cord with the right twist.

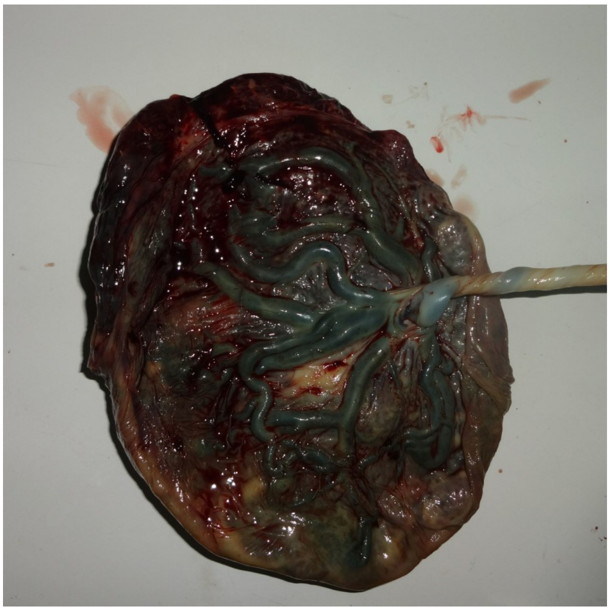

Fig 2. Placentae with the magistral chorionic vasculature. Note the uniform diameter of the blood vessel.

al., 2006). However, the influence of twisting pattern on the branching of chorionic blood vessels, the shape of the placenta and umbilical cord insertion are largely unknown. The present study focuses on the factors influencing the branching pattern of the chorionic vasculature for a better understanding of the pathogenesis of IUGR.

The aim of the study was to define the role of umbilical cord vasculature pattern on the shape of the placenta and position of the umbilical cord insertion. The objective of the study was to find any association between umbilical cord twist and morphology of placenta.

MATERIALS AND METHODS

This was a prospective analytical study done in Sri Manakula Vinayagar Medical College, Puducherry. The sample size was calculated using a previously done pilot study. The study was approved by the institutional ethical committee (Reference number 21/2016). After obtaining consent, a total of 313 placentae were included in the study. Fused placentas, the placenta of mothers with gestational diabetes mellitus, pregnancy-induced hypertension, mixed and absent twist patterns of cord were excluded from the study. After delivery, the umbilical cord was clamped and cut 5 cm from the fetal insertion, and care was taken not to milk the cord (as the latter might affect the UCI). The placentas were tagged with the patient details and preserved in 10% formalin for 24 hours. The direction of umbilical cord twist was determined by placing it vertically and using the limbs of the capital letter V. Umbilical cords with left and right twist had grooves of coiling parallel to the respective limbs of the V (Fig. 1) (Edmonds et al., 1954).

The length of the cord from the cut end to the placental insertion was measured in centimeters. A coil was taken as one complete 360-degree spiral course of the umbilical vessels. The UCI was measured as a total number of complete vascular coiling / total length of cord in centimeters (Chitra et al., 2012; Jessop et al., 2014). A longitudinal incision was made close to the placental end of the umbilical cord. The umbilical arteries were cleared from the surrounding Wharton's jelly; umbilical arteries and Hyrtl's anastomosis were identified and cleaned. The external diameter of umbilical arteries and Hyrtl's anastomosis was measured using a digital Vernier caliper with an accuracy of 0.01mm. The average of the two umbilical arteries yielded the umbilical artery diameter (UAD), and the difference between the two values yielded the mean difference in umbilical artery diameter (MDUAD).

The placental membranes were trimmed and washed properly to remove blood clots. When the ratio between the diameter of chorionic blood vessels at the periphery (point of dipping deeper into the placenta) and at the umbilical cord insertion site was ≤ 0.5, it is categorized as dispersal type; more than 0.5 it is categorized into magistral type (Fig. 2) (Verma et al., 2012). The placental weight (PW) was measured and placed over an osteometric board in such a way that the fetal surface faced upwards. The umbilical cord attachment was placed towards the right lower quadrant of the photographic field whenever there was an eccentric or marginal attachment. A ruler with centimeter markings was placed in the photographic field for the purpose of calibration. A digital camera with the 15-megapixel resolution was fixed to the osteometric board at a uniform distance of 20cm from the placentae to minimize errors of parallax. Superior view photographs were taken and transferred to PowerPoint software 2010.

Lines were drawn to represent the maximum length (L) and breadth (B) of the placentae. The center (C) of the placenta was defined as the intersection between L and B. The longest diameter (major axis) was either L or B depending upon which was greater. The other diameter was termed the minor axis. The point of the umbilical cord insertion was marked (I) (Fig. 3) (Pathak et al., 2010).

Images were analyzed using Image J software (version 1.48d). The CCI was calculated using the following formula:

$$\text{CCI} = \frac{\text{Distance of umbilical cord insertion from center}}{\text{Half of the longest diameter of the placenta}}$$

(Pathak et al., 2010)

The EI was calculated using the following formula:

$$\text{Eccentricity} = \sqrt{1 - \left(\frac{\text{minor axis}}{\text{major axis}}\right)^2}$$

(Pathak et al., 2010)

The mean and standard deviation of UAD, MDUAD, HA, UCI, PW, EI and CCI were calculated. The Shapiro-Wilk test for normality was performed and they showed a non-normal distribution. The difference in the parameters between umbilical cords with a right and left twist was estimated using the Mann-Whitney U test, the difference in branching pattern between twist and prevalence of HA was estimated using chi-square test (p-value of less than 0.05 was considered statistically significant).

RESULTS

The proportion of umbilical cords with left and right twist were 246 (78.6%) and 67 (21.4%) respectively. The mean and SD of the parameters of the study has been discussed in Table 1. Significant differences were observed in UAD (p=0.036**) and UCI (p<0.001**) between cords with left and a right twist. The prevalence of vasculature pattern was 170 disperse (69.10%), 76 magistral (30.90%) in a left twist and 32 disperse (47.76%), 35 magistral (52.24%) in right twist. Fisher's exact t-test for chorionic vasculature pattern revealed a significant difference between left and right twist (p=0.001**).

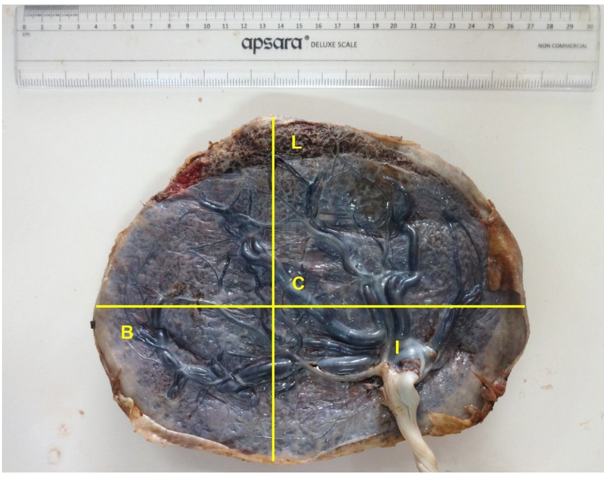

Fig 3. Method of determining EI and CCI. L – Maximum length, B – Maximum breadth, C – Centre of the placenta, I – Insertion of umbilical cord.

DISCUSSION

Previous studies have discussed the prevalence of twisting pattern and its obstetric or neonatal outcome. These studies included cases with chromosomal anomalies, intrauterine growth retardation and intrauterine demise, and have discussed the association of right twist with these pathological conditions (Kalish et al., 2003). To the best our knowledge, this is the first study to focus on the prevalence of twisting pattern in an uncomplicated population and its role in determining the coiling index, placental vasculature, the shape of the placenta and umbilical cord insertion.

The proportion of umbilical cords with a left twist (78.6%) was higher than right twist (21.4%). This is in concurrence with previous studies in which the prevalence of left twist varied from 65 to 79% (Qin et al., 2002; Kalish et al., 2003; Gupta et al., 2006). In the present study, the mean UAD of umbilical cords with left and right twists were 2.07±0.58 and 2.21±0.53 mm respectively. The significant difference (p=0.036**) between the UAD indicates an association of high caliber blood vessel and right twist and possibly increased blood flow. The findings suggest that the increase in UAD among right twisted cords could be a compensatory mechanism to overcome higher vascular resistance. The lack of significant difference in the values of MDUAD disapproves the theory that twisting is due to the unequal difference in diame-

Table 1. Difference in parameters between left and a right twist. SD = Standard deviation; P value < 0.05 indicates significant difference **

Parameters	Left twist (n=246) Mean±SD	Right twist (n=67) Mean±SD	Statistics (p value)
Mean umbilical artery diameter (UAD) in mm	2.07±0.58	2.21±0.53	0.036**
Mean difference in umbilical artery diameter (MDUAD) in mm	0.48±0.42	0.42±0.36	0.545
Diameter of Hyrtl's (HA) anastomosis in mm	2.26±0.93	2.40±0.77	0.106
Umbilical coiling index (UCI)	0.19±0.08	0.24±0.08	< 0.001**
Placental weight in grams	557.4±93.6	540.4±84.4	0.401
Eccentricity index (EI)	0.43±0.16	0.44±0.16	0.619
Cord centrality index (CCI)	0.41±0.18	0.41±0.16	0.754

ter of umbilical arteries.

Ullberg et al. (2003) found that the Hyrtl's anastomosis in placentas from IUGR had a varied anatomy and a relationship between its width and the symmetry of the supply areas of each umbilical artery. The absence of HA can result in discordant umbilical arteries, a condition often associated with non-central insertion of the umbilical cord (Predanic and Perni, 2006). The diameter of HA for left and right twist were 2.26 ± 0.93 and 2.40 ± 0.77 mm. Previous studies yielded similar values ranging from 1 to 2.3 mm (Raio et al., 2001; Ullberg et al., 2003). The prevalence of absence of HA among twisting patterns were 43 cords (17.48%) with a left twist and 16 cords (23.88%) with the right twist. There was no significant difference in diameter of HA between left and a right twist. Hence the role of twisting pattern in influencing HA is negligible.

Previous studies have categorized coiling into 3 groups, <10th percentile is hypocoiled; 10th-90th percentile is normocoiled; >90th percentile is hypercoiled. Both hypocoiling and hypercoiling of cords are associated with adverse neonatal outcome (Gupta et al., 2006; Chitra et al., 2012; Clerici et al., 2013; Dutman and Nikkels, 2015). But recently, a systematic review on UCI observed that the association of abnormal cord coiling and the clinical outcome are generally based on high risk and complicated pregnancy which cannot be applicable to a low-risk population (Jessop et al., 2014). In the present study, the coiling was estimated using UCI which is a direct measure of twists per length. The UCI of cords with left and right twists were 0.19 ± 0.08 and 0.24 ± 0.08 respectively. The significant difference between the UCI (p<0.001**) indicates a higher coiling among the right twist. These values varied from previous Indian studies of 0.14 ± 0.08 and 0.09 ± 0.08 for left and right twist, where the left twist is more coiled than the right. The difference in values could be due to the pathology like prematurity, meconium stained, and pregnancy-induced hypertensive cases included in the previous study (Gupta et al., 2006). Another study on unselected low-risk population of 1,082 placentas yielded a mean value of 0.20 ± 0.09 (Jessop et al., 2014). The values of UCI from previous studies vary over a wide range from 0.13-0.20 (Gupta et al., 2006; Jessop et al., 2014). The UCI obtained from the present study is higher for a normal population which does not mandate for an adverse pregnancy outcome and can serve as the standard reference for proper interpretation.

Few studies have found an association between blood flow velocity and placental weight but could not find any for circularity of placenta or cord deviation (Salavati et al., 2016). This suggests that placental weight is a direct measure of blood flow rather than shape and centrality of cord. Placental weight also reflects the expanding growth of the chorionic disc, increasing thickness of chorionic villi vasculature, and increasing surface exchange of nutrients (Salafia et al., 2006). The placental weight of left and right twisted cords were 557.4 ± 93.6 gm and 540.4 ± 84.4 gm. The placental weight was lower for a right twist but not significant enough to be taken into consideration.

Verma et al. (2012) correlated the chorionic vasculature of the placenta with the birth weight of neonates, and found the birth weight of neonates in the dispersal pattern were lower than the magistral pattern. In the present study, the prevalence of vasculature pattern was 170 disperse (69.10%), 76 magistral (30.90%) in a left twist and 32 disperse (47.76%), 35 magistral (52.24%) in right twist. A significant difference of chorionic vasculature pattern was elicited between left and right twist (p=0.001**). From previous studies, it has been observed there is a predominant disperse pattern, but a higher prevalence of magistral pattern among right twisted cords is intriguing and suggests higher blood flow to overcome the vascular resistance. A significant difference in chorionic vasculature pattern with no difference in placental weight questions the role of the vasculature in determining the weight. The authors speculate that, apart from chorionic vasculature, there can be other factors at action which influence the placental weight. Further histological studies are needed to support this theory. Understanding the aforementioned mechanism would enable us to find the reason behind preferential magistral patterning of chorionic vessels in diamniotic-monochorionic placentas with Twin to twin transfusion syndrome (Paepe et al., 2005).

The placenta shape varies from round, oval or irregular. The EI represents the placental shape, a value of 0 indicates circularity, while values near 1 indicate an elliptical shape. In the present study, a mean EI of 0.43±0.16 for left twist and 0.44±0.16 for right twist suggests that the commonly occurring shape in the normal population is non-circular. A similar study done on normal singleton placentae showed a mean EI of 0.49±0.17 (Pathak et al., 2010). The shape of the placenta is determined by the chorionic vascular growth, and abnormal placental shape has been reported with placental abruption and preterm delivery (Costa et al., 2008; Yampolsky et al., 2008). The EI observed in the present normal population showed no relationship with the twisting pattern.

The CCI represents the umbilical cord insertion from the chorionic plate margin: the lower the value of CCI, the closer is the umbilical cord insertion towards the center. The non-centrality of the umbilical cord insertion is associated with a sparse chorionic vasculature and thereby reduced placental efficiency (Yampolsky et al., 2009). In the present study, a mean CCI of 0.41±0.18 for left twist and 0.41±0.16 suggests that the umbilical cord is paracentral in a normal Indian population. Previous studies have noted a similar mean CCI value of 0.36 ± 0.21 (Pathak et al., 2010). The alteration in the twist did not affect the position of umbilical cord insertion.

To summarize, twisting of the cord might play a minor role in altering the blood flow and determining the vasculature pattern, but not sufficient enough to influence the placental weight, the shape of the placenta and umbilical cord insertion. However, the higher prevalence of magistral pattern of chorionic vasculature among cords with a right twist should be taken into consideration, and needs further umbilical artery flow velocimetry studies to appreciate its role.

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Abbreviations

CCI – cord centrality index

EI – eccentricity index

HA – Hyrtl's anastomosis

IUGR – intrauterine growth retardation

MDUAD – mean difference in umbilical artery diameter

PW – placental weight

UAD – umbilical artery diameter

UCI – umbilical coiling index

REFERENCES

BENIRSCHKE K, BURTON GJ, BAERGEN RN (2012) Pathology of the Human Placenta. 6th ed. Springer-Verlag, New York.

CHITRA T, SUSHANTH YS, RAGHAVAN S (2012) Umbilical coiling index as a marker of perinatal outcome: an analytical study. *Obstet Gynecol Int*, 2012:213689.

CLERICI G, ANTONELLI C, RIZZO G, KANNINEN TT, DI RENZO GC (2013) Atypical hemodynamic pattern in fetuses with hypercoiled umbilical cord and growth restriction. *J Matern Fetal Neonatal Med*, 26(6): 558-562.

COSTA SL, PROCTOR L, DODD JM, TOAL M, OKUN N, JOHNSON JA, WINDRIM R, KINGDOM JCP (2008) Screening for placental insufficiency in high-risk pregnancies: is earlier better?. *Placenta*, 29(12): 1034-1040.

DUTMAN AC, NIKKELS PG (2015) Umbilical hypercoiling in 2nd- and 3rd-trimester intrauterine fetal death. *Pediatr Dev Pathol*, 18(1): 10-16.

EDMONDS HW (1954) The spiral twist of the normal umbilical cord in twins and singletons. *Am J Obstet Gynecol*, 67: 102-120.

GORDON Z, EYTAN O, JAFFA AJ, ELAD D (2007) Hemodynamic analysis of Hyrtl anastomosis in human placenta. *Am J Physiol Reg Integ Comp Physiol,* 292 (2): 977-982.

GUPTA S, FARIDI M, KRISHNAN J (2006) Umbilical coiling index. *J Obstet Gynecol India*, 56(4): 315-319.

JESSOP FA, LEES CC, PATHAK S, HOOK CE, SEBIRE NJ (2014) Umbilical cord coiling: Clinical outcomes in an unselected population and systematic review. *Virchows Archiv*, 464(1): 105-112.

KALISH RB, HUNTER T, SHARMA G, BAERGEN RN (2003) Clinical significance of the umbilical cord twist. *Am J Obstet Gynecol*, 189(3): 736-739.

LAAT MWM, NIKKELS PGJ, FRANX A, VISSER GHA (2007) The Roach muscle bundle and umbilical cord coiling. *Early Hum Dev*, 83(9): 571-574.

LACRO RV, JONES KL, BENIRSCHKE K (1987) The umbilical cord twist: origin, direction, and relevance. *Am J Obstet Gynecol*, 157: 833-838.

PAEPE ME, KONINCK P, FRIEDMAN RM (2005) Vascular distribution patterns in monochorionic twin placentas. *Placenta*, 26: 471-475.

PATHAK S, HOOK E, HACKETT G, MURDOCH E, SEBIRE NJ, JESSOP F, LEES C (2010) Cord coiling, umbilical cord insertion and placental shape in an unselected cohort delivering at term: Relationship with common obstetric outcomes. *Placenta*, 31(11): 963-968.

PREDANIC M, PERNI SC (2006) Antenatal assessment of discordant umbilical arteries in singleton pregnancies. *Croatian Med J*, 47(5): 701-708.

QIN Y, LAU TK, ROGERS MS (2002) Second-trimester ultrasonographic assessment of the umbilical coiling index. *Ultrasound Obstet Gynecol*, 20(5): 458-463.

RAIO L, GHEZZI F, DI NARO E, FRANCHI M, BALESTRERI D, DURIG P, SCHNEIDER H (2001) In-utero characterization of the blood flow in the Hyrtl anastomosis. *Placenta*, 22(6): 597-601.

SALAFIA CM, CHARLES AK, MAAS EM (2006) Placenta and fetal growth restriction. *Clin Obstet Gynecol*, 49 (2): 236-256.

SALAVATI N, SOVIO U, MAYO RP, CHARNOCK-

JONES DS, SMITH GCS (2016) The relationship between human placental morphometry and ultrasonic measurements of utero-placental blood flow and fetal growth. *Placenta*, 38: 41-48.

ULLBERG U, LINGMAN G, EKMAN-ORDERBERG G, SANDSTEDT B (2003) Hyrtl's anastomosis is normally developed in placentas from small for gestational age infants. *Acta Obstet Gynecol Scand*, 82(8): 716-721.

VERMA R, PRASAD R, MISHRA S, KAUL JM (2012) Vascular pattern of chorionic blood vessels of placenta and its correlation with the birth weight of neonate. *Int J Morphol*, 30(3): 952-955.

YAMPOLSKY M, SALAFIA CM, SHLAKHTER O, HAAS D, EUCKER B, THORP J (2008) Modeling the variability of shapes of a human placenta. *Placenta*, 29(9): 790-797.

YAMPOLSKY M, SALAFIA CM, SHLAKHTER O, HAAS D, EUCKER B, THORP J (2009) Centrality of the umbilical cord insertion in a human placenta influences the placental efficiency. *Placenta*, 30(12): 1058-1064.