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Morphological Variations of Umbilical Cord of Full-Term Foetuses - Correlation with Maternal and Newborn Parameters

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Abnormalities in the development and site of insertion of umbilical cord can cause problems which have the potential to affect maternal and foetal health. The aim of the present study was to assess the gross features of umbilical cord (UC) of singleton pregnancies and to find out the possible association to newborn parameters and maternal parameters at term. An observational, descriptive pilot study was carried out with one hundred placentas. All ethical principles for human research were followed. Adequately preserved placenta with no gross abnormalities were included. Placentae belonging to hypertensive mothers and mothers with gestational diabetes were excluded.The present study had 53% placentas with central, 36% eccentric, 3% furcuate and marginal and 5% with velamentous insertions. Correlation between the umbilical cord insertion site and birth weight was observed. Further investigations are required among velamentous insertion pattern for correlations with maternal blood group.

Key words: Umbilical cord, Insertion patterns, Placentae, Foetus, Maternal Parameters

Introduction

The umbilical cord (UC) connects the foetus with the placenta which contains two arteries and one vein surrounded by Wharton's jelly. Normal development and central pattern of insertion UC is expected, any deviation from the morphology can have potential affect maternal and foetal health [22, 28]. The UC transfers oxygen and nutrients to the growing fetus throughout pregnancy. Numerous studies have pointed out the importance of normal UC morphology with implications on insertion site. Abnormal positioning of UC can be associated with numerous maternal complications and fetal distress [13, 19, 20, 23, 24]. Variations in the site of insertion of umbilical cord are thought to result from the process known trophotrophism in which the chorionic frondosum or the early placenta "migrates" with advancing gestation to ensure a

better blood supply from a more richly vascularised area[24,17]. The UC insertion site can be subdivided into four categories: central, paracentral, marginal/battledore, and velamentous/membranous. The central/paracentral category is considered as the normal condition. It is well accepted that UC insertion is considered aberrant when attached within 2 cms of the edge of the placental disk (marginal/battledore) or when it is inserted into the chorioamniotic membranes (velamentous/membranous), which often leads to fetal death. Incidence of velamentous is 1.1% in singleton births and 8.7 to 16% in twin deliveries [3].Thus umbilical cord insertion to the placenta is divided as central, eccentric, marginal and velamentous, as it is related to the chorionic plates. Another type of variation is furcate insertion, in which umbilical cord branch before its insertion to placenta [8, 15, 24, 27,30].

Complications during delivery and other pathologies i.e; intrauterine growth retardation (IUGR), preterm labour and trophotrophism can be the outcome of peripherally inserted UC [14] Furcate type of insertion with a prevalence of (0.5-1%) has more volume of villi, villous trophoblast and syncytial knots [27]. Early impaired foetal development can be correlated with genetic and environmental associated mechanisms which are associated with and placental functioning and UC parameters [7, 14]. Oxygen and nutrienttransfer capacity of the placenta is highly associated with the vascular network within the chorionic villi. Abnormal UC insertion is associated with smaller placenta [7] and lower placental vessel density [16]. The placental insufficiency and fetal growth is dependent on abnormal cord insertion which may increase the susceptibility to antenatal risk [5, 6]. Optimal placentation will result in a central insertion of the UC which facilitate optimal growth of the foetus throughout gestation. Therefore, the aim of the present study was to evaluate the gross features of UC and correlating it to the newborn parameters and maternal parameters at term.

Materials and Methods

An observational, descriptive pilot study was carried out with one hundred placentas. All ethical principles for human research were followed and ethical approval was obtained from the Institutional Ethics Committee of the medical college from where data was collected. The inclusion criteria were the adequately preserved placenta with umbilical cord after delivery with no gross abnormalities from all pregnant ladies above 18 years of age. Placenta belonging to hypertensive mothers and mothers with gestational diabetes were excluded.

Collection of specimens: We collected a total of 100 specimens (placenta with intact UC) by random method of sample collection for a period of six months obtained from the department of obstetrics and gynecology (OBG). The mode of delivery and birth order were assessed. Samples were preserved in buffered 10% neutral formalin after the analysis at the department of anatomy for future assessments if required any.

Method of study: Specimens were cleared, dissected and observed carefully macroscopically for umbilical parameters namely insertion (central, eccentric, marginal, velamentous, furcuate) by measuring its distance from the placental margin, cord length (Normal between 55-60cm, long >60cm, short <40cm), cord vessels (number of arteries and veins), placental weight (Normal between 500-600gm, Overweight >600gm, Underweight <500gm), placental diameter (Normal between 20-22 cm, long

>23cm, short <19cm) and cord design (Normal, False knots and true knots). Details were photographed, recorded and analyzed.

New born parameters analyzed were baby weight (Normal 2.5-4.2kg, Overweight >4.2kg, Underweight <2.5gm), head circumference (Normal 33-35cm, more>37cm, less<31cm), baby length (Normal 50-52cm, more >55cm, less <45cm). Gestational age is defined as early term: when your baby is born between 37 weeks, 0 days and 38 weeks, 6 days, full term: when your baby is born between 39 weeks, 0 days and 40 weeks, 6 days, late term: when your baby is born between 41 weeks, 0 days and 41 weeks, 6 days. [12].

Maternal parameters assessed were maternal age, birth order, mode of delivery, previous birth manner and blood groups were noted down for further correlations. We have obtained consents from parents of the newborns involved in this study.

Results

The placental attachment of UC and the site of insertion were noted down for 100 samples. We had 74 normal and 26 caesarean section (CS) births. Among the samples, 53 placentas showed the central insertion, 36 eccentrically insertion of cords. In 3 specimens we found furcuated insertion and 5 specimens had velamentous insertion and 3 specimens showed marginal insertion (**Fig. 1 A-E**).

Normal cord length was seen in 89 cases with an average of 53.14 cm. Short cords were noted among 10 cases which had central and eccentric insertions. Single placenta had long cord. Ninety six cases showed normal cord vasculature were four cases showed abnormal vascular pattern with single umbilical artery (SUA) (**Fig. 1 Y**). Placental weight was normal in 70 cases, were 24 placentas weighed less than the normal attached by central and eccentric insertion to UC and 6 placenta had increased weight than normal which had furcuate,velamentous and eccentric insertions of UC.There were 61 placentas with normal diameter, 28 with increased diameter and 11 were decreased diameter. Normal design and pattern of UC were observed in 37 specimens with eccentric insertions predominantly. False knots were seen in 63 cords with central insertions (**Fig. 1 X**). No cord exhibited true knot.

New born parameters analysis showed that 89 infants had normal birth weight with an average of 2.88 Kg. No incidence of large for date baby was observed. 11 babies were underweight with their UC had central (5) and eccentric (6) insertions. Head circumference and baby length of 96 infants was normal with an average of 33.7 cm and 48.4 cm respectively. No incidence of large head circumference and increased baby length was observed. Among 4 babies with decreased head circumference and baby length had central (1) and eccentric (3) insertions of their UC attachment.

We did not find any significant association between the weight of the placentas with either gestational age of the foetus (Pearson's correlation, $r = 0.082$, $P = 0.42$) or the term of birth (Pearson's correlation, $r = 0.084$, $P = 0.40$). We also did not find any significant association between the length of the placental cord with either gestational age of the foetus (Pearson's correlation, $r = 0.064$, $P = 0.53$) or the term of birth (Pearson's correlation, $r = -0.012$, $P = 0.92$).

Considering the birth order, fifty four baby were born from the women who had

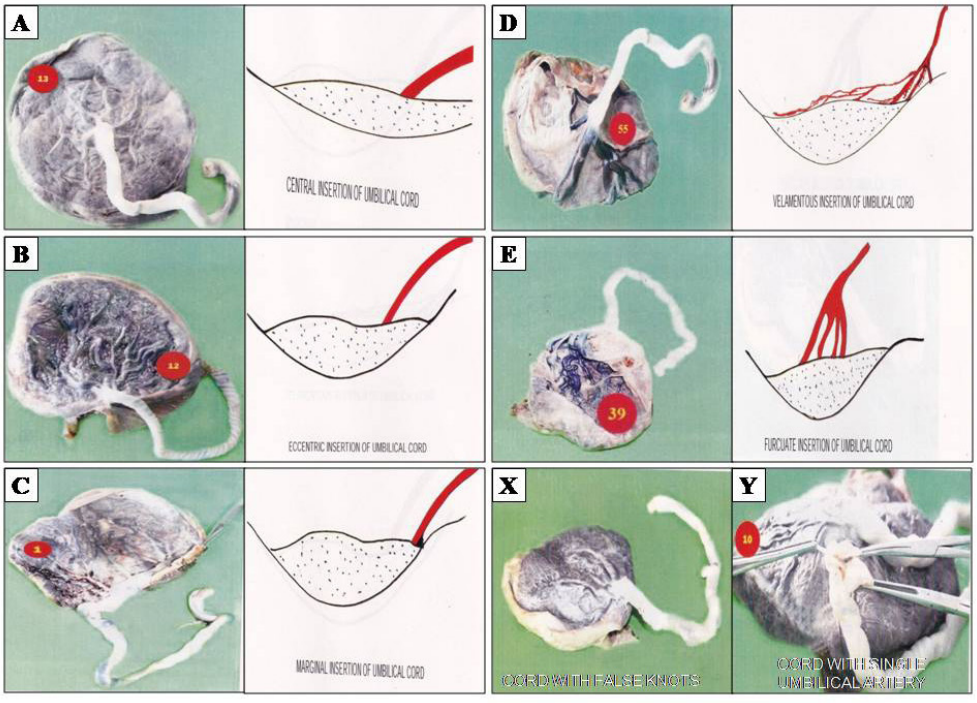

Fig. 1. Umblical cord insertions. A – Central,B – Marginal, C – Eccentric, D-Furcuate, E – Velamentous, X – Cord with false knots, Y – Cord with single umbilical artery

given birth for the first time, thirtyone from second, fourteen from third and one baby from fourth delivery. We did not find any significant association between the age of the mother and the mode of delivery (CS vs. normal). Maternal blood group analysis showed Rh^{+ve}andRh^{-ve}mothers of all blood groups had central, eccentric and marginal insertions. When velamentous insertion of cord was taken in to special consideration because of its complexities associated we had four B^{+ve} mothers and a single O^{-ve} mother. Further investigations are required among this insertion to reach to a conclusion for blood group correlations.

Discussion

The UC morphology and parameters and the deviations from optimal features under certain conditions can affect the foetus. A better understanding of cord function and design is essential for finding solutions to UC related complications. Abnormal UC's design can result in cord rupture, entanglement, complications during of labor and uterine malfunction.

The present study statistics showed 53% placentas with central insertion, 36% eccentric insertion, 3% furcuated and marginal insertions each and 5% specimens with velamentous insertion. Studies of Pilotto et al. [18], Rolschau et al. [25] and Ebbing

et al. [7] had also reported the highest prevalence of central followed by eccentric and marginal insertions.The study samples were more than the present study in other studies by different authors but the percentages of the fore mentioned insertions were similar to the present study. MK SS and MC VM report a high prevalence for eccentric insertions than central insertion in their study [21]. None of the comparative study had furcuate insertion for UC's. When velamentous insertion was taken in to account present study percentage for the same was more than studies of Rolschau et al. of 1.15% of velamentous insertions in their studies. Ebbing et al. had 1.5% and Brouillet et al. [4,7] had 0.95% of velamentous insertions in their sample populations. These percentages when compared to present study show a decreased trend. In the present study infant birth weight at term was reported within normal limits among central and peripheral UC insertions. Brouillet et al. [4] reported an association with fetal growth restriction in terms of low birth weight among UC insertion except central insertion. This result suggests that central UC attachment is relevant for attaining optimal foetal parameters i.e. foetal weight and in peripheral cord insertions there was higher occurrence of foetal growth retardation.

In the present study normal cord length was seen in 89 cases with an average of 53.14 cm. Short cords were noted among 10 cases which had central and eccentric insertions. Single placenta had long cord. Abaidoo et al. [1] reports an average cord length of 47.04 cm and the study also reports 21.56% of short cords which is more than the present study which had only 10% of short cords. When present study was compared to studies of Appiah et al. [2] the percentage of short cords were more in the compared study i.e 29.62%, where increased cord length percentages were similar to the present study. While comparing with the previous study of UC vasculature, it was noted that the SUA was more significant in the present study. The present study had 4% of SUA against 1% in studies of Geipel et al. and 0.2-1.1% in studies of Fernando et al. [9,11].

New born parameters analysis showed that 89 infants had normal birth weight with an average of 2.88 Kg. No incidence of large for date baby was observed.11 babies were underweight with their UC had central and eccentric insertions. Thomson et al. reports that the placental weight and size were not directly proportional to the birth weight [29]. In contrast to this, Shanklin et al.[26] reported low birth weight foetus, when cord is inserted marginally or velamentously. Grbesa et al. [10] reported decreased birth weight in foetus when cord was inserted eccentrically which is similar to the present study but increased birth weight was seen in babies with marginal insertion of cord to placenta. This is not observed in the present study.

Conclusion

In conclusion, correlation between the umbilical cord morphology with maternal and foetal parameters has been highlighted in our study. Extensive studies are required to better understand the pathophysiological mechanisms that facilitate for difference in pattern of UC insertions. To improve neonatal outcome and to avoid maternal complications during delivery, adequate antenatal checkups and ultrasound monitoring for umbilical cord abnormalities is inevitable. Further investigations are required among velamentous insertion to reach to a conclusion for maternal blood group correlations.

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Table 1. Morphological features of umbilical cord

CATEGORY	CONDITION	n (%)			
PARAMETERS		C	E	M	F	V
UC Insertion		53	36	3	3	5
UC Length	Normal	48	31	3	3	4
	Long	0	1	0	0	0
	Short	5	4	0	0	1
UC Vasculature	Normal	49	36	3	3	5
	Abnormal	4	0	0	0	0
Placental weight	Normal	35	26	3	2	4
	More	0	4	0	1	1
	Less	18	6	0	0	0
UC Design	Normal	12	24	1	0	0
	False Knots	41	12	2	3	5
	True Knots	0	0	0	0	0

Abbreviations: UC – Umbilical cord, C – Central, E – Eccentric, M – Marginal, F – Furcuate, V-Velementous