

MORPHOLOGICAL VARIATIONS OF THE “BABY’S SUPPLY LINE”

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ABSTRACT

To contribute to the sparse information on dimensional variations of umbilical cords in Ghana, 124 placentae with attached umbilical cords were studied. The placentae were obtained from the University of Science and Technology Hospital between 2000 and 2002. Average cord length was 47.04cm (SD 12.8cm) with the shortest cord being 5.5cm and the longest 75.50cm. By empirical definition, 21.56% of the cords were Short whereas, 78.44% were long. Most of the umbilical cords (63%) had empirically eccentric attachments to their placentae; 20.48% had central and 16.52% had marginal attachments respectively. Occurrence of furcate insertion of umbilical cord vessels into the placenta was 28% and non-furcate insertion was 72%. These quantitative data provide baseline values for further investigation.

Keywords: *umbilical cords, morphology, length, attachments, looping, insertion*

INTRODUCTION

The human umbilical cord is a narrow, complex structure that connects the foetus to the placenta. The umbilical cord is sometimes called the baby’s “supply line” because it serves as a conduit for foetal vessels going to and from the mother. Knowledge about the umbilical cord is important because the vessels in the cord are an essential part of the foetal circulation. The umbilical cord has also been found to be a marker of intrauterine complications (Berg and Rayburn, 1995). Morphological variations in the umbilical cord due to its susceptibility to malfor-

mations, lesions, mechanical and iatrogenic events throughout pregnancy, labour and delivery, collectively referred to as umbilical cord accidents, are said to be possible causes of foetal injury or death (Harman, 1995). These morphological variations include; umbilical cord attachments to the placenta, extreme umbilical cord lengths, Wharton’s jelly content, cord tensile strength, shape, cord looping, cord knotting and umbilical cord vessel morphology and number (Schindler, 1991).

Clinical significance has been imputed to certain variations of umbilical cord and disposition. Cer-

tain slight variations in the morphological features of umbilical cords have been thought to affect the structure and function of the umbilical cord (Mills *et al.*, 1983; Miller *et al.*, 1982). Length variations in umbilical cord range from total absence to a length of 300cm (Stallabrass, 1960; Berg and Rayburn, 1995). A linkage between abnormal cord lengths and neurological abnormalities as well as intelligence quotient (I.Q) values has been reported (Naeye, 1992; Berg and Rayburn, 1995). Umbilical cord abnormalities such as true knots, nuchal coils and body loops have also been suggested to have a close association with extreme umbilical cord lengths, resulting in foetal risks such as foetal malformations, injury and stillbirth (Naeye, 1992). It has been postulated that there may be an increased risk of umbilical cord accidents when a combination of factors such as length of cord, thinness, marginal insertion, nuchal cord and true knot are present in the same foetus (Harman, 1995; Smotherman and Robinson, 1998).

According to Collins (1992) and Flamm (1999) short cords (<30cm) could interfere with foetal heart rate patterns and result in an increased need for caesarean section, forceps and vacuum extraction during delivery. In addition, relatively short cord lengths, further compromised by foetal entanglement causes loss of elasticity which could interfere with delivery as well. Umbilical cords that are 70cm or longer are considered as long cords (Sornes, 2000) are reported to be associated directly with poor foetal outcome and umbilical cord accidents, especially; foetal entanglement, true knot (sometimes multiple) and torsion (Sornes, 2000). Available literature shows that cords from male foetues tend to have longer lengths than female cords, whilst term vertex foetuses also have longer lengths than term breech foetuses (Sornes, 2000). Additionally multigravida cords might have longer lengths than primagravida cords (i.e. the first pregnancy having a shorter length than the third) (Miller *et al.*, 1982; Sornes and Bakke, 1989).

Twin gestations were also suggested to have foetuses with discordant and shorter lengths than singletons (Sornes, 2000). Umbilical cord function however, does not appear to be impaired by cord length; therefore venous return from the placenta to the foetus was maintained regardless of length (Wright and Ridgway, 1990).

It is estimated that more than 7.6 million perinatal deaths occur world-wide; each year 4.3 million of these are foetal deaths (Schindler, 1991; Sornes, 2000). Ninety-eight percent of perinatal deaths have been said to take place in developing countries, and the perinatal mortality rate is estimated to exceed 55 per 1000 births, which is five times higher than in developed countries (Schindler, 1991). Currently, very little is known about the incidence of foetal deaths resulting from umbilical cord malformations in Ghana. It is therefore considered necessary to establish a comprehensive baseline data on umbilical cord length, cord diameter, cord vessel morphology, cord-placental insertion, and foetal outcome. The distribution of these indices in developing countries is also largely unknown. The occurrence of fetal compression risk based on cord location on the placenta and insertion of umbilical blood vessels is also unknown (Harman, 1995). The present study sought to provide baseline data on the morphological variations of human umbilical cords.

MATERIALS AND METHODS

Sample collection

A total number of one hundred and twenty-four (124) umbilical cords along with placentae were collected from the University of Science and Technology Hospital between 2000-2004. The samples were labelled and preserved in 10% formalin solution. The umbilical cord segment, from the cut end to the point of insertion on the placenta, was measured with a tape measure (Plate 1) within 30 minutes after fixation.

The measured cord stub attached to the umbilicus of the foetus, which was usually 2.50 cm was added to the length of the cord attached to the placenta. The position of the cord on the placenta



Plate 1: A measuring tape alongside an umbilical attached to its placenta

was also recorded. The insertion point of the cord in relation to the placenta, was located and described as either centric, eccentric or marginal. The insertion of the umbilical vessels into the placentae was examined and described as either furcate (when the vessels were separated from each other before their insertion) or non-furcate (when they were covered by a sheath of Wharton’s jelly to their point of insertion). The number of vessels in each umbilical cord was counted and recorded by snipping a bit of each umbilical cord and observing the number of lumina present. The cords were critically examined for knot formation and recorded.

RESULTS

Umbilical cord length, shape and insertion

The range of cord length obtained was 5.0-75.5 cm with a mean of 47.04cm (SD 12.8 cm). Using the mean cord length in the literature (≥ 40 cm) as a marker, the distribution of short and long cords were 21.56% and 78.44% respectively. This difference in mean cord length was statistically significant. It was also found that the proportion of long cords was significantly different from that of short cords using a confidence interval of 95%. A large majority (69.60%) of the cords were between 41.50 cm and 55.00 cm in length. The diameter of the respective cords was in the range of 1.50 cm to 3.20 cm with a

mean cord diameter of 2.1cm (SD 0.004), using a 95% confidence interval. A large majority of the cords had a diameter between 2.0 cm and 2.5 cm. Out of a total number of 124 placentae, central (Plate 2), marginal (Plate 3) and eccentric (Plate 4) insertions constituted 20.48%, 16.52% and 63% respectively.



Plate 2: a photograph of an umbilical cord with central attachment to its placenta



Plate 3: a photograph of an umbilical cord with marginal attachment to its placenta



Plate 4: a photograph of an umbilical cord with eccentric attachment to its placenta

Umbilical cord vessels

The occurrence of 2-, 3- and 4-vessel cords were 1.00%, 96.00% and 2.20% respectively, indicating that a large majority of the cords had 3 umbilical cord vessels. Out of the 124 umbilical cords studied, one (0.80%) had a single umbilical artery. About 8.64% had furcated attachments (Plate 5) whereas the remaining 91.36% were non furcated (Plate 5) in their modes of insertion to the placenta. No velamentous umbilical cords were seen.

Cord knots and cord looping

Knot formation was observed in about five cords. One had a true knot and the remaining four were false knots and the cords in which they were found were considerably long. Looping was quite a prominent feature in the cords. About 50 out of the 124 cords studied presented with cord looping. The occurrence of Hyperhelical (coiled) hypohelical (straight), twisted and spiral cords were 36%, 18%, 36% and 10% respectively.

DISCUSSION

In the present study cords less than 40.0cm were classified as short, those greater than 40.0 cm were categorized as long. Based on this criterion there were more long cords (78.44%) than short



Plate 5: a photograph of two umbilical cords showing furcated insertion (left) and non-furcated insertion (right)

(21.56%). This difference in mean cord length was statistically significant. It could be speculated that "normal" cord length should be greater than 40 cm. While opinions differ with regard to the limits of normal cord length, umbilical cord lengths between 40 cm and 70 cm have been suggested to be normal (Harman, 1995), whereas short umbilical cords are defined as a total length of less than 40cm (Sornes and Bakke, 1989;Harman, 1995). The significance of long umbilical cords resides in the fact that they may be directly associated with poor foetal outcome and umbilical cord accidents such as foetal entanglement, knot formation (multiple) and torsion. Foetal cord entanglements in particular may reduce the volume of blood flow to the foetal brain and limbs and subsequently cause neurological disturbances (Sornes, 2000). Other researchers have reported that, umbilical cord function is not impaired by long cords suggesting that venous return from placenta to foetus is maintained regardless of the length of the umbilical cord (Wright and Ridgway, 1990).

In contrast, relatively short cords may interfere with the mechanics of labour, as the foetus may not be able to descend because the cord length limits it (Hershkovitz *et al.*, 2001). In such cases, Caesarean section, forceps and vacuum extraction would be the only choice left for safe delivery of the foetus. Cords of insufficient length may also result in breech presentation, prolonged labour, abruptio placenta and uterine inversion (Sornes and Bakke, 1989). Short cords are found in newborns with early intrauterine constraint and in those with gross structural or functional limb defects that limit intrauterine movement (Miller *et al.*, 1982).

Umbilical cord length is the only factor associated and documented as a definite risk factor for poor foetal outcome (Hershkovitz *et al.*, 2001). It has been reported that there is an association of abnormal cord length with neurological abnormalities and low IQ values in children who are born with very long umbilical cords (Sornes, 2000).

In the present study it was observed that umbilical cords were commonly positioned eccentrically on placentae (Plate 4). The overall incidence of 83.48% for a combined centric/eccentric cord insertion is comparable with the observations of Addai *et al.* (1994). They reported an overall incidence of 74% for combined centric/eccentric cord insertion and 26% for marginal/peripheral cords out of 121 sampled umbilical cords. Fox (1978) reported an incidence of 15% for marginal cords. It is possible that the position and arrangement of marginal insertions may make the cords prone to vessel compression or rupture leading to foetal death (Sornes, 2000). Many researchers have reported that umbilical cords are usually inserted centrally or eccentrically with marginal insertions being rare in occurrence (Salafia, 1990).

It has also been shown that amongst the different types of cord insertions, marginal insertions are generally pose more risk, as a little torsion or stress is likely to cause disruption of blood flow along the cord. It is known that aberrations of umbilical cord attachment can affect the function of the cord. Marginal cords have also been clinically linked with various congenital anomalies (Kamitomo *et al.*, 1999). In the present study it was not possible to do a follow-up on the foetuses with marginal umbilical cords.

A large majority (96%) of the cords in this study had 3 umbilical cord vessels. Three umbilical cord vessels is normal and adequate for proper fetal development and survival. It is well documented that in humans, the "normal umbilical cord" has an arterial pair that is mildly helical around a straight vein (Cohen *et al.*, 1992; Martinez *et al.*, 1995; Pierce *et al.*, 2001). Therefore differences in umbilical cord vessel morphology may be a risk factor for the foetus and may predispose the foetus to umbilical cord accidents.

Out of the 124 umbilical cords studied, one (0.80%) had a single umbilical artery (SUA). Cords with a single umbilical artery, two-vessel cords and four-vessel cords have been reported (Martinez *et al.*, 1995). SUA has been associated

with stillbirths, with an incidence of 3% - 20%. Malformations due to inadequate blood supply and brain damage among fetuses with SUA have been reported to be as high as 46% (Martinez *et al.*, 1995; Schimmel and Eidelman, 1998). In a report Sornes, (2000) it was found that about 27% of livebirths with structural anomalies were associated with SUA while in specimens obtained from early abortions, foetal deaths and autopsies, SUA was seen in 66.3%. Four-vessel-cords have also been associated with foetal abnormalities (Martinez *et al.*, 1995; Schimmel and Eidelman, 1998). Cases of five or more cords, are the numerous variations associated with conjoined twinning (Martinez *et al.*, 1995).

The incidence of umbilical vessel attachments was found to be 8.64 % and 91.36% for furcate and non-furcate respectively. The occurrence of non-furcate vessels was significantly higher than furcate ones probably suggesting that non-furcate vessels are normal vessel attachments whereas furcate vessels could result in injury and haemorrhage due to lack of adequate protection for these vessels. Pierce *et al.* (2001) reported that the mode of umbilical cord insertion has no significant effect on the examined components, and such differences are probably the effect of biological variations during normal placental and fetal development. However, more recently it has been reported that the occurrence of foetal compression risk based on cord insertion and location is still unknown (Sornes, 2000).

The cord diameter in the present study was found to be between 2.00cm to 2.50 cm this however compares quite favorably with the findings of Sornes, (2000) who described the typical umbilical cord as having a fairly uniform diameter of 2.0-2.5 cm. In the present study the minimum cord diameter was about 1.5 cm. Cord diameter may be related to its Wharton’s jelly content. It may be that umbilical cords of larger diameter have a large amount of Wharton,s jelly whereas cords with smaller diameters have rela-

tively little jelly content. Wharton’s jelly has a gelatinous consistency and may serve as a cushion for the umbilical vessels. Therefore lean umbilical cords may also be more vulnerable to compression and breaking due to lack of tensile strength. However in a recent study by Amiel-Tison and Stewart (1994), it was reported that cords with little or inadequate Wharton’s jelly may suggest poor nutrition and lack of glycogen in fetal tissues.

The occurrence of Hyperhelical (coiled) hypo-helical (straight), twisted and spiral cords were 36%, 18%, 36% and 10% respectively. Out of 124 umbilical cords studied, one had knot formation and another had constrictions. The coiled and twisted features found in cords could be as a result of tension, stress or strain resulting from the weight of the foetus which is borne normally by the elastic nature of the umbilical cord. However excessive pressure on cords could compromise the elasticity of cords leading to the occurrence of straight cords. In addition, excessive coiling and twisting could however lead to the interference in blood flow through the vessels.

Knot formation was seen in about five umbilical cords. Although four of these knots were false, the cords in which they were found were considerably long in length (65-75.5 cm). False cord knots are quite frequent in normal pregnancies, and appear to be due to umbilical artery loops within the cord (Sornes, 2000; Hershkovitz *et al.*, 2001). Knotting in the umbilical cord is a sequence of events which creates a loop of cord counter to the twist (torque) applied by foetal movements (which may be due to blood flow disturbances). This loop passes over the foetal body with time and occasionally, a bunch of cord loops make the false impression of a cord knot.

False umbilical cord knots may have little clinical significance whereas true knots of the umbilical cord although rare may lead to obstruction of the fetal circulation and subsequent intrauterine death (Hershkovitz *et al.*, 2001). In addition, evidence of fetal heart rate changes, umbilical blood flow

reduction, decreased fetal movement has been reported with cord knotting (Sornes, 2000).

Looping was quite a prominent feature in the cords. Out of the 124 umbilical cords, about 91 presented with cord looping. This could be compared to the loops in the cord of a telephone receiver. Looping is an adaptative anatomical feature, used by the human body to contain long objects in a small space (Lacro *et al.*, 1987). Cords with relatively wide diameters exhibited less looping than cords with smaller diameters. This might be a way for the smaller cords to make up for the inadequate tensile strength and adapt to torsion. It has been suggested by Strong *et al.* (1993) that non-coiled cords and poorly coiled cords are structurally less able to resist external compressive forces which may lead to preterm delivery, operative delivery for fetal distress and intrauterine death.

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Ben-Arie *et al.* (1995) reported that Hyperhelical (coiled) hypohelical (straight), true knot and constriction were 1%, 5%, 1-25% and 1% respectively. Utsu and Maeda (1991) and Glanfield and Watson (1986) stated that stillbirth was associated with torsion. Randall (1989) however proposed that umbilical cords under the influence of torsion could be untwisted, with Vandeplassche *et al.* (1986) confirming that torsion-compromised umbilical cords were different from natural helices which cannot be untwisted. These torsion twists, if not resolved as early as possible could cause blood flow obstruction through the umbilical cord when the ability of the cord to absorb the torque is exceeded (Lacro

et al., 1987). In another study, Collins and Collins (2000) indicated that tension, if applied to umbilical cords could lead to kinking which invariably blocks blood flow.

CONCLUSION

In the present study the overall incidence of 85.18% for a combined centric/eccentric cord insertion suggests that umbilical cords studied were commonly positioned eccentrically or centrally on placentae and the vessels were inserted in a non-furcate fashion. Results of the present study provide for the first time detailed baseline data on the variations in the morphological characteristics of the umbilical cord such as length, type of insertion, number of vessels and type of vessel attachment.

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