THE UNIVERSITY OF ZAMBIA

SCHOOL OF MEDICINE

CORRELATES OF HUMAN UMBILICAL CORD LENGTH AND SIGNIFICANCE OF ITS DISTRIBUTION INTO THE CHORIONIC PLATE IN ZAMBIAN INFANTS AT THE UNIVERSITY TEACHING HOSPITAL, LUSAKA

DR SANGEETA PATHAK

DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT AND FOR THE DEGREE OF MASTER OF MEDICINE IN OBSTETRICS AND GYNAECOLOGY

2002

DEDICATION

I DEDICATE THIS WORK TO RAHUL, AKANKSHA AND AKSHITA WHO HAVE BEEN A SOURCE OF INSPIRATION IN EVERYTHING I DO

ACKNOWLEDGEMENTS

I would like to thank my supervisor Dr Yusuf Ahmed for his advice and untiring help throughout the period of this study up to the writing up of the final work- without his help this study would not have easily been achieved.

I am deeply indebted to Professor A. Agboola, as without his support and encouragement this study would never have been started.

I am grateful to Mr Joseph Banda for his assistance in the computer analysis of my data and typing out of the final script.

I would like to thank Ms Rosemary Wilombe for indefatigable secretarial duties starting from typing of the research proposal right up to the final script. I owe her a great debt of gratitude.

I wish to thank Dr Operance Munachitobwe for his help, advice and continued encouragement.

I am pleased to acknowledge the helpful assistance of my colleagues and friends for their advice and encouragement throughout the period of the study.

STATEMENT

I HEREBY STATE THAT THIS DISSERTATION IS ENTIRELY THE RESULT OF MY OWN PERSONAL EFFORT. THE VARIOUS SOURCES TO WHICH I AM INDEBTED HAVE BEEN CLEARLY INDICATED IN THE BIBLIOGRAPHY AND ACKNOWLEDGEMENTS.

SIGNED: Sangeeta Pathak.

DR SANGEETA PATHAK

DECLARATION

I HEREBY DECLARE THAT THIS DISSERTATION HEREIN PRESENTED FOR THE DEGREE OF MASTER OF MEDICINE IN OBSTETRICS AND GYNAECOLOGY HAS NOT BEEN PREVIOUSLY SUBMITTED EITHER WHOLLY OR IN PART FOR ANY OTHER DEGREE AT THIS OR ANY OTHER UNIVERSITY NOR IS IT BEING CURRENTLY SUBMITTED FOR ANY OTHER DEGREE.

SIGNED:.....Sangeeta Pathak.....

DR SANGEETA PATHAK

APPROVED BY:.....

DR YUSUF AHMED (SUPERVISOR)

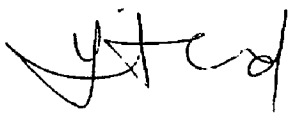
APPROVAL

THIS DISSERTATION OF DR SANGEETA PATHAK IS APPROVED AS FULFILLING PART OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF MEDICINE IN OBSTETRICS AND GYNAECOLOGY BY THE UNIVERSITY OF ZAMBIA.

SIGNATURES

_____

_____



_____

ABSTRACT

There are few documented studies of human umbilical cord length and its insertion into the chorionic plate. However abnormal umbilical cord length (either excessive or shortened) is a known risk factor for adverse perinatal outcome. Long cords have been associated with cord prolapse, entanglement, torsion and thrombosis whereas short cords are associated with rupture of the cord, failure of the fetus to descend in labour and also associated with some congenital fetal anomalies and malpresentation.

Umbilical cord may have central, eccentric, marginal or velamentous insertion into the chorionic plate of the placenta. Central and eccentric insertions account for more than 90% of insertions and have no clinical importance. Peripheral insertions (marginal and velamentous) have been associated with vessel rupture, fetal growth restriction, stillbirth, neonatal death or malformed infants.

This was a prospective study at UTH in 1997, of 916 Zambian infants, to study the average length of the umbilical cord of infants 28 weeks of gestation age or more, and the prevalence of distribution of umbilical cord insertion into the chorionic plate. Length and insertion were, in addition, correlated with maternal and fetal factors.

The mean, median and mode of umbilical cord length were 50.7, 50.0 and 50.0 cms respectively and were consistent with studies from elsewhere. The range was from 21.0 to 110.0 cm. Almost 75% of umbilical cord lengths in the series were between 40 and 60 cm. There was a tendency for cord length to increase towards term though, in view of the wide variation in lengths, this was not statistically significant. There was a weak positive correlation between cord length and birthweight ($r=0.24$) and also placental weight ($r=.22$). There was no difference in cord length by gender or by presentation when considered alone. However male infants delivered by vertex had a longer mean cord length than female infants delivered by breech (51.0 cm vs 46.6 cm, $p=0.01$). No obvious adverse fetal or perinatal outcome due to a fetus having an excessively long or short umbilical cord was found in this study, though stillborn infants had slightly shorter cords.

Central insertion of the umbilical cord was found in 47.5 % of the cases while eccentric, marginal and velamentous insertions accounted for 50.5, 2.0 and 0 % respectively. There was no significant association between various insertions and infant birthweight and placental weight, and neither was the fate of the infant fetus adversely affected.

This study helps in establishing a baseline for cord length and insertions and will assist as a baseline for further studies on umbilical cord length and placenta.

TABLE OF CONTENTS

DEDICATION i

ACKNOWLEDGEMENTS ii

STATEMENT iii

DECLARATION iv

APPROVAL v

ABSTRACT vi

CONTENTS vii

LIST OF TABLES AND FIGURES viii

LIST OF ABBREVIATIONS ix

INTRODUCTION AND LITERATURE REVIEW 1

OBJECTIVES 8

STUDY JUSTIFICATION 8

HYPOTHESES 9

METHODS 10

RESULTS 13

DISCUSSION 31

CONCLUSIONS 39

STUDY LIMITATIONS 40

RECOMMENDATIONS 40

REFERENCES 41

LIST OF TABLES AND FIGURES

Table or Figure	Page
Table 1: Frequency distribution of maternal Age (n=916)	14
Table 2: Frequency distribution of parity (n=916)	15
Table 3: Frequency distribution of gestational Age (n=916)	16
Table 4: Frequency distribution of birthweight (n=916)	17
Table 5: Frequency distribution of type of delivery (n=916)	18
Table 6: Frequency distribution of gender of newborn (n=916)	18
Table 7: Frequency distribution of outcome (n=916)	19
Table 8: Frequency distribution of umbilical cord length (n=916)	20
Table 9: Frequency distribution of umbilical cord length (n=916)	21
Table 10: Frequency distribution of placental weight (n=916)	22
Table 11: Frequency distribution of mean cord length by gestation category (n=916)	23
Table 12: Frequency distribution of mean birthweight by cord length category (n=916)	24
Table 13: Mean cord length by birthweight category (n=916)	25
Table 14: Difference in cord length by gender of infant (n=916)	27
Table 15: Difference in cord length by presentation of infant (n=916)	27
Table 16: Difference in cord length by gender and presentation of infant (n=916)	28
Table 17: Outcome and cord length of infants > 2,500g (n=740)	29
Table 18: Outcome and cord length of infants (n=916)	30

Figure 1: Histogram of umbilical cord lengths (n=916)	20
Figure 2: Pie chart of umbilical cord insertions (n=916)	21
Figure 3: Mean cord length by gestation categories (n=916)	22
Figure 4: Mean birthweight by cord length categories (n=916)	23
Figure 5: Mean cord length by birthweight categories (n=916)	25
Figures 6 and 7: Scattergrams of cord length and birthweight	26

ABBREVIATIONS

A/S	-	Apgar Score
CI	-	Confidence Interval
FHR	-	Fetal Heart Rate
FSB	-	Fresh Stillbirth
IUFD	-	Intrauterine Fetal Death
IUGR	-	Intrauterine Growth Retardation
MSB	-	Macerated Stillbirth
NST	-	Non Stress Test
RR	-	Risk Ratio
SGA	-	Small for Gestational Age
SVD	-	Spontaneous Vaginal Delivery
UTH	-	University Teaching Hospital

INTRODUCTION AND LITERATURE REVIEW

The College of American Pathologists, in order to advance and promote better understanding of placental pathology have encouraged clinicians to do studies on the placenta and umbilical cord. The College published in 1995 guidelines to encourage properly designed placenta studies with appropriate outcome parameters necessary to draw conclusions and discourage routine placenta examination except in stillborn fetuses. Tragedies such as perinatal death or severe neurological impairment are increasingly recognised as being caused by pathological conditions of the umbilical cord. These frequently develop long before labour and delivery and cannot be prevented by even the best of obstetric care. Under these circumstances, examination of the umbilical cord and placenta in the delivery room as well as in the pathology laboratory can be a crucial contribution to the investigation of instances of pregnancy failure.

Complications associated with umbilical cords.

Infants with long or short cords have more cord complications, especially entanglements, torsion and thrombosis. True knots and cord prolapse are associated with long cords, whereas short cords have a higher incidence of peripheral placental insertion, rupture, haematoma and stricture. Other obstetric complications associated with short cord are breech and other fetal malpresentations, delayed completion of the second stage of labour, abruption and uterine inversion.

The umbilical cord, the "lifeline of the fetus" is extremely variable in length and at term is usually 55-60 cm long (Heifetz et al, 1996). For all placentae, the length of umbilical cord are measured in the delivery room, because this is the one place where a complete assessment can be made, including of the segment left on the infant or being sent for other studies. Both long and short cords have been associated with increased possibility of long-term infant problems. True cord lengths at term less than 32 cm, or more than 100 cm, warrant further study as they may be implicated in various problems in the infant (Kaplan, 1996). Boyd and Hamilton (1970) have reported on lengths at various gestations as outlined below. This reflects the increasing length with increasing gestation.

Gestation (month)	Length of fetus (mm)	Average cord length (cm)	Range (cm)
Third	31 – 60	6	2.3 - 10.5
Fourth	61 – 100	15	5 - 25
Fifth	101 – 150	25	14.5- 45
Sixth	151 – 200	28	21 – 48
Seventh to Term	200 – 340	35	22 – 48 (or more)

Boyd and Hamilton (1970) in a historical review, refers to studies by Hyrtl in the 1870s and others, and had reported the average length of the full-term umbilical cord as being between 50 - 60cm - the extremes typically being 30-80 cm. In the same review, mention is made of Shordania, who in 1929 recorded an average length of 60 cm in a series of 421 cords, the range being 35-104 cm. Similarly, Fog in the 1930s as described by Boyd, reported measurements of average cord length of 54.8 cm for 1,476 premature infants, the average for the 8,000 cases in the combined series being 59.6 cm.

Although growth of the umbilical cord continues beyond term, most of the cord's length is achieved by the end of second trimester (Desilva, 1992). Cord length appears to be

largely determined by genetic factors and forceful stretching by the developing fetus, the more the tension, the longer the cord (Desilva, 1992).

The point of insertion of the umbilical cord into the chorionic plate is variable. The umbilical cord may have a central, eccentric, marginal (battledore) or velamentous (membranous) insertion. Central and eccentric insertions account for more than 90% of cord insertions and have no clinical importance. Marginal insertion (5-7%) may be more susceptible to vessel rupture and has been associated with fetal growth retardation, stillbirth and neonatal deaths. The incidence of velamentous insertion (up to 1-2%) increases with maternal cigarette smoking, advanced age, diabetes mellitus, multiple births, malformed infants and in-vitro fertilization pregnancies. Velamentous vessels are subject to compression, thrombosis and tears with fetal haemorrhage, especially those that pass in front of the cervical os (vasa previa).

There are few documented studies of human umbilical cord length and its insertions into the chorionic plate. Such studies have shown a positive relationship between cord length, fetal weight and placental weight, while other studies have shown no relation between different cord insertion and fetal outcome.

Studies of cord length and insertions and their relationship to pregnancy outcome.

In a Nigerian study, Agboola (1978) reported that the mean cord length of 602 Nigerian babies was 57.8 cm. Mean fetal weight and placental weight were 3.23 kg (SD = 0.42) and 596.8 gm (SD = 105.68) respectively, and there was a significant correlation between cord length and fetal weight. The correlation between cord length and other fetal and maternal variables studies were not significant. However, fetal weight and placental weight were found to be significantly correlated.

In a later study in Nigeria by Agboola (1982) of 440 women to assess the clinical significance of the distribution of umbilical cord insertion into the chorionic plate, it was reported that central insertion was found in 26.5% of cases while eccentric, marginal, and velamentous insertions accounted for 65.5, 9.2 and 1.8%respectively. There was no significant association between the various insertions and variation in fetal and placental weight and neither was the fate of the fetus adversely affected. Agboola suggested that it is probably the pattern of distribution and anastomosis of the umbilical vessels within the chorionic plate that is responsible for the previously reported differences in the size and the state of well-being of the fetus and placenta, and not the type of umbilical cord insertion itself.

Adinma (1993), in another Nigerian study of 1,000 consecutive deliveries, showed that cord length varied between 15-130cm (mean 51.5 cm) with increasing length with gestation. No relationship was found with parity, maternal age or the sex of baby. Longer cords were associated with cord encirclement and unstable lie, and shorter cords with breech presentation, transverse lie and twin birth.

Wu et al (1996) in a study based in Taiwan, performed multivariate analysis of the relationship between umbilical cord length and obstetric outcome of 1,087 deliveries. The findings, as in the Nigerian studies, were that male fetuses had longer cord length than female fetuses and in vertex presentation there was a longer cord length than in breech. The cord length and placenta weight were significantly related to the birthweight. In Wu's study, birthweight and the presence of meconium staining were correlated with secondary arrest in labour. However, there was no significant correlation between umbilical cord length and fetal wellbeing. Other factors like maternal age, gestational age (greater than 28 weeks), parity, fetal outcome or intrauterine fetal wellbeing were not related to umbilical length.

Grbesa and Durst-Zivkovic (1996) reported on a study from Croatia looking at neonatal and placental factors in relation to the mode of umbilical cord insertion. Neonatal and placental factors and compartment volumes of placental parenchyma in relation to variations of cord insertions in normal human placenta were examined. They concluded that the different sites of insertion are probably the effect of biological variations during the placenta and fetal development.

In a retrospective case control study, Eddleman et al (1992), evaluated the clinical significance and sonographic diagnosis of velamentous insertions of 82 cases. The authors concluded that although cases with velamentous insertions of umbilical cord indeed had more intrapartum complications and lower birthweight than controls, routine non-targeted, obstetric ultrasound failed to detect any case of velamentous insertions This included three cases of vasa previa, suggesting that prenatal sonographic diagnosis of this condition is uncommon. Similarly, Heinonen et al (1996) in Finland, retrospectively

analyzed 216 pregnancies complicated by velamentous cord insertions. Only one case of velamentous insertion was diagnosed prenatally even though 80 of the patients had undergone routine ultrasound examinations. Regarding the association between velamentous cord insertions and adverse pregnancy outcome in singleton pregnancies, Heinonen at al also assessed the diagnostic usefulness of the non-stress test (NST) and Doppler ultrasound in this condition. They reported that velamentous insertion was associated with higher risk of low birthweight (Odds Ratio –OR- 2.32), small for gestation age (OR 1.54), preterm delivery (OR 2.12), low Apgar Score at 1min and 5 min (ORs 1.76 and 2.47 respectively) and abnormal fetal heart rate (FHR) pattern (OR 1.59).

A Norwegian study by Sornes (1995) on umbilical cord encirclements and fetal growth restriction showed that the cord encirclements were indeed associated with fetal growth restriction, the severity of the restriction being positively related to the number of encirclements. Umbilical cord encirclements are also associated with a relative lengthening of the umbilical cord with a positive correlation between cord length and fetal weight. Sornes concluded that umbilical cord encirclements are associated with fetal growth restriction.

Benirschke (1994) reviewing lesions of the umbilical cord, commented that many pathological features of the umbilical cord adversely affect fetal well being. Excessively long or short umbilical cords may be the cause of haematomas and thrombosis of cord vessels and the placental surface, thus causing fetal death and /or thrombocytopenia. In other cases, fetal hypoxia and central nervous system damage are possible outcomes. Thrombosis is also frequently induced by velamentous insertions of the cord, as are haemorrhages when the membranes rupture during parturition. Entangling and knotting

of the cord, especially of excessively long cords, may lead to similar lesions and fetal death.

The literature illustrates that few studies have been done on the placenta and umbilical cord. Apart from the Nigerian studies reported by Adinma and Agboola, no study has been performed in Zambia or in the region. Nevertheless in the curriculum of student midwives and medical students, examination of the placenta and umbilical cord is stressed. Furthermore in assessing an adverse perinatal outcome, it would be useful to know the features of the umbilical cord.

The present prospective study has been designed to investigate the average umbilical cord length of Lusaka infants, the distribution of the point of insertion of the umbilical cord into the chorionic plate and to relate it to some maternal and fetal factors and compare the findings with published studies. This has never been documented and would provide an opportunity to compare it to previously published data from elsewhere in Africa and other regions.

OBJECTIVES

The objectives of this study are:

- To determine the range of umbilical cord length of Zambian newborn infants.
- To correlate the cord length with maternal and fetal factors.
- To establish the prevalence of the distribution of umbilical cord insertion into the chorionic plate.
- To correlate the distribution to maternal factors (age, parity, gravidity) and fetal factors (gestational age, weight, fetal presentation, sex, intrauterine fetal wellbeing and fetal outcome).

STUDY JUSTIFICATION

There are few documented studies of human umbilical cord length and its insertion into the chorionic plate. However such studies are important because the vessels contained within the cord are essential parts of the fetal circulatory system. Either longer or shorter cords and different types of cord insertions especially marginal and velamentous may have various antenatal, perinatal or postnatal effects. The result of this study would help assess poor pregnancy outcomes in terms of placental and umbilical cord pathology and provide a basis for counseling patients. The data would also guide any further studies on the umbilical cord and the placenta.

HYPOTHESES

The hypotheses of this study are that:

- the distribution of umbilical cord length and cord insertions of Zambian babies is different from that of other races.
- there is little growth in cord length after 28 weeks as suggested by other studies
- cord length is related to fetal outcome (particularly short cord length is related to poor outcome)
- cord insertions into the chorionic plate are related to fetal outcome.

METHODS

This was a prospective study undertaken at the Department of Obstetrics and Gynaecology, University Teaching Hospital (UTH). 1000 infants of greater than 28 weeks gestation, who delivered consecutively at UTH, were included during the period commencing August 1997. Women with multiple gestation and with unknown gestational age were excluded from this study to be in conformity with studies like those of Adinma in Nigeria (1993) discussed in the Literature Review.

Umbilical cord length of the above infants was measured within 30 minutes of delivery. The standard procedure at UTH is for the umbilical cord to be clamped and cut at between 3 and 5 cm from the infant's abdomen soon after delivery. The placenta is normally delivered by controlled cord traction. The umbilical cord and placenta are then removed to the 'Sluice Room' within the labour ward. All placenta, umbilical cord and membranes are examined routinely by the attending midwife within 30 to 60 minutes after delivery.

- Number of vessels in the cord was noted as was the point of insertion of the umbilical cord into the chorionic plate was noted and recorded as being either central, eccentric, marginal or velamentous.
- The cord was then excised from the point of insertion into the chorionic plate, blood was drained from the placenta as much as possible, adherent blood clots from the placenta maternal surface were removed and the placenta weighed on a balance scale without stripping off the membranes.
- The umbilical cord was measured using an accurate non-stretchable fixed measuring scale. (This procedure was similar to that described by Agboola in 1978 and 1982).

The newborn baby was weighed within 30 minutes of delivery, as is standard practice at UTH.

The data capture sheet illustrated below was used and included: mother's age, parity, gestational age, cord length, insertion of umbilical cord into the chorionic plate, weight of the body, Apgar Score at 5 minutes and sex of the newborn. Other points noted in data collection were type of delivery and antenatal complications if any.

Data Sheet

Mother's age:

Gravidity and Parity

Gestational age (weeks)

Type of delivery (SVD, Breech, Instrumental):

Outcome (Alive/IUFD/Stillborn):

Apgar Score (5 min):

Birthweight (kg):

Sex of newborn

Umbilical cord length (cm):

Cord insertion into the chorionic plate (central, eccentric, marginal, velamentous):

Placental weight (grams)

Any problems in pregnancy:

Data Analysis and Presentation

The data collected (see Data sheet previously) was collated and presented descriptively in tabular form and as figures as appropriate.

Comparative analysis was performed for selected fetal and maternal variables. Student's 't' test, correlation coefficients were estimated using EPI Info version 6. Significance was set at <5% ($p<0.05$).

Fetal variables that were analysed were:

Gestational Age	-	Less than 37 completed weeks.
		37 completed weeks or more
Weight	-	Less than 2,500 grams
		More than or equal to 2,500 grams
Sex	-	Male / Female
Fetal outcome	-	Alive or dead (Including fresh and macerated Stillbirth)
Apgar score (5minute)-		categories : 0; 1-6; 7,8; 9,10.

Stillbirth or livebirth

Ethical Considerations

Although there were no ethical issues identified. The standard of care of the umbilical cord separation at birth and examination subsequently were not altered in any way. All data was obtained from the case files without name identifiers. However formal ethics approval for the study was obtained from the Research Ethics Committee of the University of Zambia.

RESULTS

The first part of the results describes the characteristics of the infants and their mothers. This includes the frequency distribution of the following:

- Maternal age
- Parity
- Gestational age
- Birthweight
- Type of delivery
- Gender of infant
- Infant outcome (Stillborn/Liveborn and Apgar score)

This is followed by the frequency distribution of:

- Umbilical cord length
- Cord insertion into the chorionic plate
- Placental weight

Covariates are presented as follows:

- Frequency distribution of cord length by gestation category
- Frequency distribution of mean birthweight by cord length category
- Frequency distribution of mean cord length by birthweight category

Comparative and further analysis is presented for:

- Differences in cord length by gender
- Differences in cord length by presentation
- Length of umbilical cord in vertex and breech presentation by gender
- Effect of cord length on outcome in fetuses $\geq$ 2500g
- Effect of insertions on infant outcome

Maternal age of women

Commencing August 1997, of the 1000 infants who delivered consecutively at UTH, only 916 singletons were eligible. The 84 who were excluded were: multiple pregnancies, those of unknown gestation, those under 28 weeks gestation (with sure dates). All others who were singleton births were included. The frequency distribution of the maternal ages of those infants is shown in table 1 below.

Table 1: Frequency Distribution of Maternal Age (n=916)

Mother's age (years)	Frequency	%
up to 19	193	21.1
20-24	266	29.0
25-29	212	23.1
30-34	124	13.5
35+	121	13.2
Total	**916**	**100**

N	916
Mean	**25.5 years**
Median	24
Minimum	12
Maximum	49
Standard Deviation	6.74
Standard Error	0.233

Parity of women

Table 2 outlines the frequency distribution of the parity of mothers whose infants were included in the study. Most were primiparas followed by those in their second pregnancy. This seems to mirror the parity of general deliveries at UTH.

Table 2: Frequency Distribution of Parity (n=916)

Parity	Frequency	%
0	333	36.4
1	156	17.0
2	123	13.4
3	112	12.2
4	75	8.2
5 or more	114	12.4
unknown	3	0.3
Total	**916**	**100.0**

N	913
Mean	**1.9**
Median	1
Minimum	0
Maximum	14
SD	2.12
SE	0.07

Gestational age

The gestational ages of the infants included in the study are provided as a frequency distribution in table 3. Over three quarters occurred at term.

Table 3: Frequency Distribution of Gestational Age (n=916)

Gestational age (weeks)	Frequency	%
28-31	48	5.2
32-36	161	17.6
37+	707	77.2
Total	**916**	**100.0**

N	916
Mean	**38.1 weeks**
Median	39.0
Minimum	28
Maximum	43
SD	3.53
SE	0.12

Birthweight

The birthweights of the 916 infants are presented as a frequency distribution in categories of 500g in table 4. Since infants were over 28 weeks gestation for inclusion, it is noted that most were between 2,500 and 3,500g in weight.

Table 4: Frequency Distribution of Birthweight (n=916)

Birthweight (g)	Frequency	%
<2000	48	5.2
2000-2499	128	14.0
2500-2999	294	32.1
3000-3499	282	30.8
3500-3999	139	15.2
4000-4499	23	2.5
4500+	2	0.2
Total	**916**	**100.0**

N	916
Mean	**2,914g**
Median	2,940
Minimum	720
Maximum	4,900
SD	589.2
SE	19.5

Type of delivery

Most deliveries were cephalic as spontaneous vaginal deliveries (SVD) (table 5).

Table 5: Frequency Distribution of Type of Delivery (n=916)

Type of delivery	Frequency	%
SVD	838	91.5
Breech	52	5.7
Instrumental	26	2.8
Total	**916**	**100.0**

Gender of newborn

There were slightly fewer male than female infants in this series (47.7 vs 52.3%) as outlined in table 6.

Table 6: Frequency Distribution of gender of newborn (n=916)

Gender	frequency	%
Male	437	47.7
Female	479	52.3
Total	**916**	**100.0**

Outcome (Alive/Stillborn) Apgar Score

The outcome of the 916 infants is tabulated in table 7. 44 (4.8%) were stillborn. 91.3% had a very good Apgar score of 9 or 10 at 5 minutes.

Table 7: Frequency Distribution of outcome (n=916)

Apgar Score (5 mins)	Frequency	%	% groups	groups
0	44	4.8	4.8	Stillborn
1	3	0.3	1.4	Poor Apgar
2	2	0.2		
3	1	0.1		
4	1	0.1		
5	2	0.2		
6	5	0.5		
7	3	0.3	2.5	Moderate
8	19	2.2		
9 and 10	836	91.3	91.3	Very good
Total	**916**	**100.0**	**100.0**	**100.0**

N	916
Mean	**8.5**
Median	9 (mode 9)
Minimum	0
Maximum	10
SD	2.03
SE	0.07

Umbilical cord length

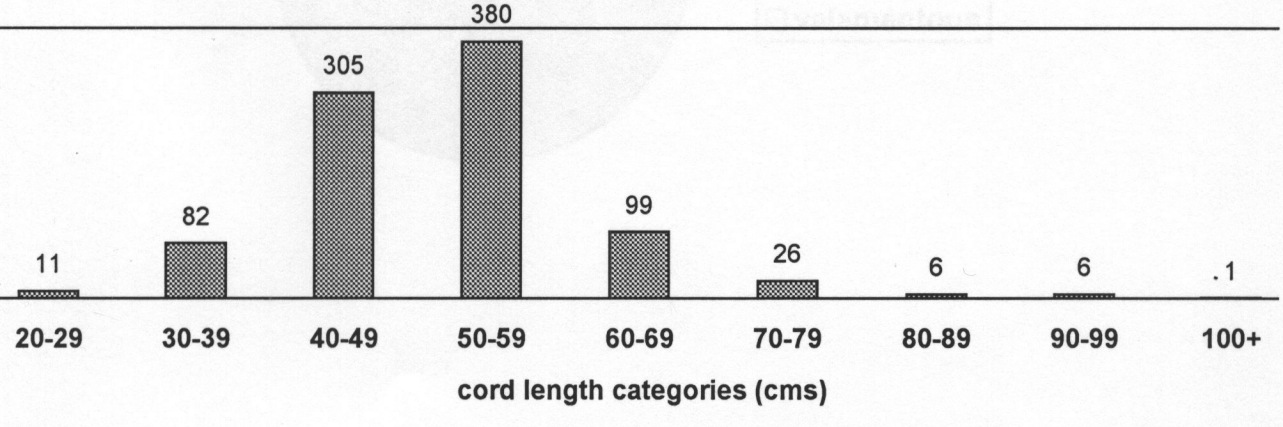
The distribution of cord length is presented in table 8 and figure 1. Categories are in units of 10 cms as in other series. The majority were between 40 and 59 cms, the mean was 50.7 cm.

Table 8: Frequency Distribution of umbilical cord length (n=916)

Umbilical cord length (cm)	frequency	%
20-29	11	1.2
30-39	82	9.0
40-49	305	33.3
50-59	380	41.5
60-69	99	10.8
70-79	26	2.8
80-89	6	0.7
90-99	6	0.7
100-101	1	0.1
Total	**916**	**100.0**

N	916
Mean	**50.7 cm**
Median	50.0 (mode 50.0)
Minimum	21 cm
Maximum	110 cm
SD	10.1
SE	0.3

Figure 1: Histogram of umbilical cord lengths (n=916)



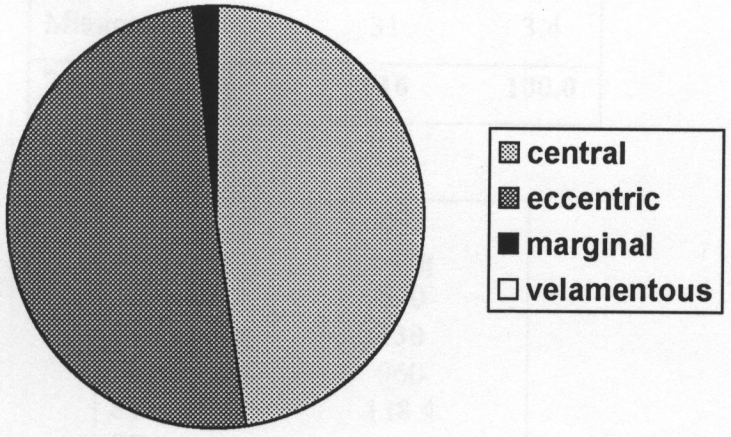
Cord insertion into the chorionic plate (central, eccentric, marginal, velamentous)

None of the 916 umbilical cords were of a velamentous insertion and only a few were marginal. Otherwise they were almost equally distributed as central or eccentric insertions as tabulated below in table 9 and shown in the figure 2.

Table 9: Frequency Distribution of umbilical cord length (n=916)

Type	Frequency	%
Central	435	47.5
Eccentric	463	50.5
Marginal	18	2.0
Velamentous	0	0.0
Total	**916**	**100.0**

Figure 2: Pie chart of umbilical cord insertions (n=916)



Placental weight

There was wide variation in the placental weights that were measured concurrently with the umbilical cords. The majority of placental weights were between 400 and 600g. In 31 cases, weights were not recorded. These are tabulated in table 10.

Table 10: Frequency Distribution of placental weight (n=916)

Placental weight (g)	frequency	%
1-99	0	0.0
100-199	1	0.1
200-299	21	2.3
300-399	63	6.9
400-499	191	20.9
500-599	268	29.3
600-699	194	21.2
700-799	76	8.3
800-899	56	6.1
900+	15	1.6
Missing	31	3.4
Total	**916**	**100.0**

N	885
Mean	**549g**
Median	520
Minimum	130
Maximum	960
SD	138.4
SE	11.7

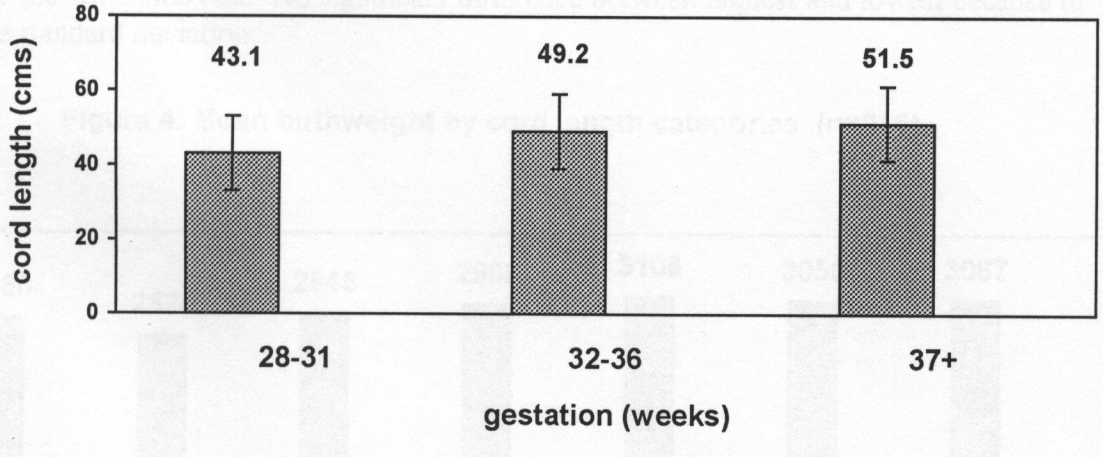
Umbilical cord length in relation to gestation

In order to assess the relationship between gestation and cord length, mean cord lengths within the categories as below are tabulated (table 11) and are presented in figure 3. Due to the large standard deviation no obvious difference could be determined between the cord length and gestation although it appeared as though babies of higher gestation had longer cords.

Table 11: Frequency distribution of mean cord length by gestation category (n=916)

Gestation (wks)	N	Mean cord length (cms)	± 1SD (cms)
28-31	48	43.1	8.2
32-36	161	49.2	9.1
37+	707	51.5	10.2
All	**916**	**50.7**	**10.1**

Figure 3: Mean cord length by gestation categories (n=916)



Birthweight in relation to umbilical cord length.

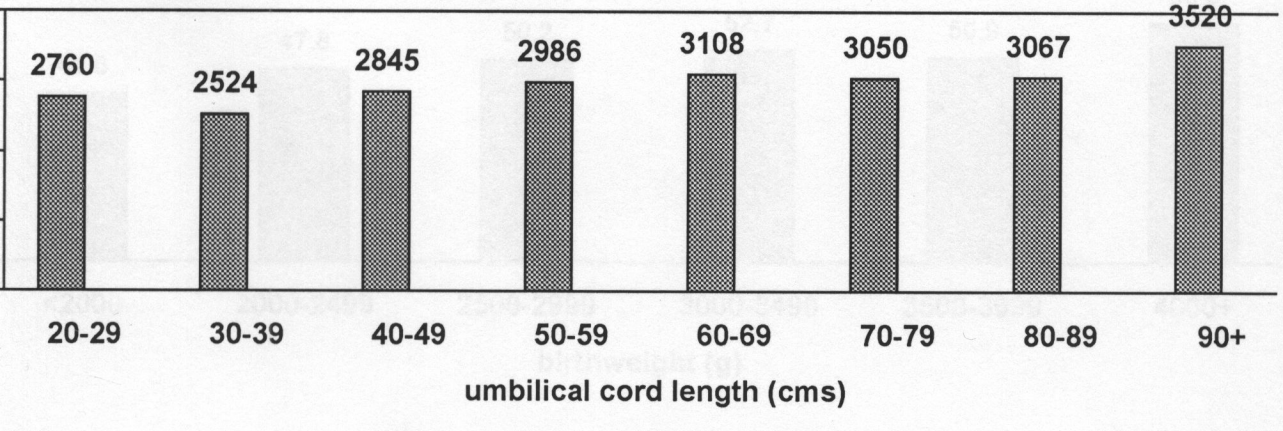
In order to assess the relationship between birthweight and cord length, mean birthweights within 10cm categories are tabulated (table 12) are presented in figure 4. Due to the large standard deviation no obvious difference could be determined between the cord length and birthweight although it appeared as though babies with longer cords were heavier.

Table 12: Frequency distribution of mean birthweight by cord length category (n=916)

Cord length (cms)	N	Mean birthweight (g)	± 1SD (g)
20-29	11	2760.0	965.2
30-39	82	2524.4	736.8
40-49	304	2845.7	578.2
50-59	379	2986.4	540.5
60-69	99	3108.3	432.4
70-79	26	3050.0	555.8
80-89	6	3066.7	638.8
90+	7	3520.0	364.2
all	**916**	**2914.0**	**589.2**

Note the wide intervals. No significant difference between highest and lowest because of large standard deviation.

Figure 4: Mean birthweight by cord length categories (n=916)



Umbilical cord length and birthweight.

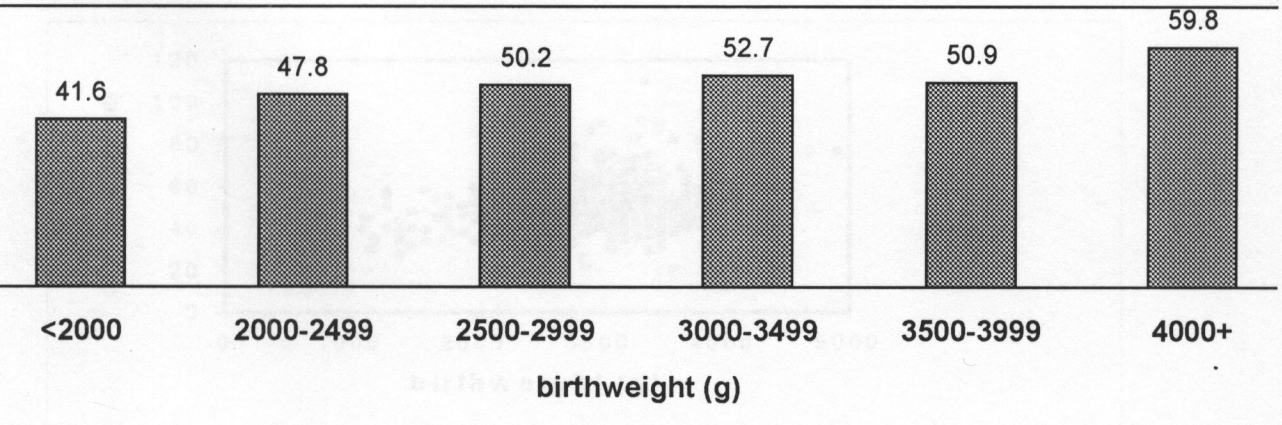
As in the previous relationship between birthweight of different cord lengths, the data is similarly presented of mean cord lengths in different birthweight categories. Heavier babies appeared to have longer cords although the large standard deviation illustrates that this was not significant (table 13 and figure 5).

Table 13: Mean cord length by birthweight category (n=916)

Birthweight (g)	N	Mean cord length (cms)	± 1SD (cm)
<2000	48	41.6	8.4
2000-2499	128	47.8	9.3
2500-2999	294	50.2	9.3
3000-3499	282	52.7	10.2
3500-3999	139	50.9	9.2
4000+	25	59.8	14.3
All	**916**	**50.7**	**10.1**

No significant difference between highest and lowest because of large standard deviation

Figure 5: Mean cord length by birthweight categories (n=916)

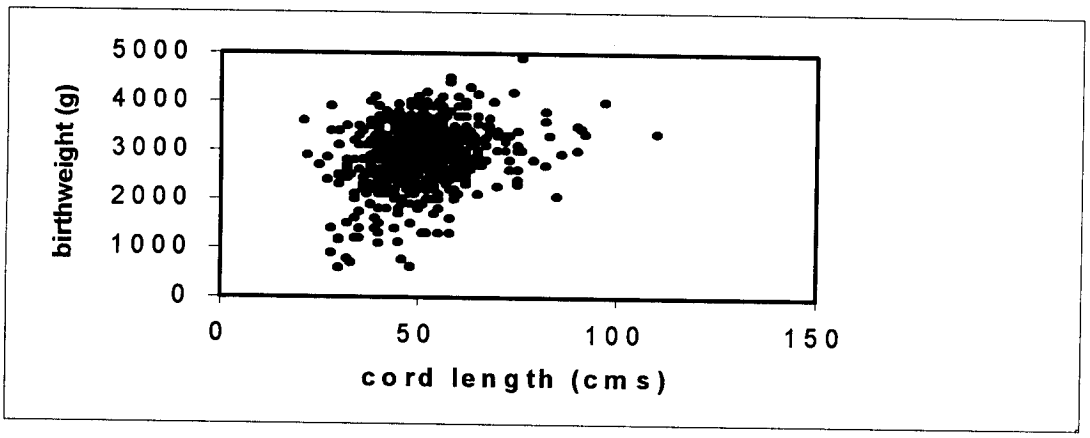


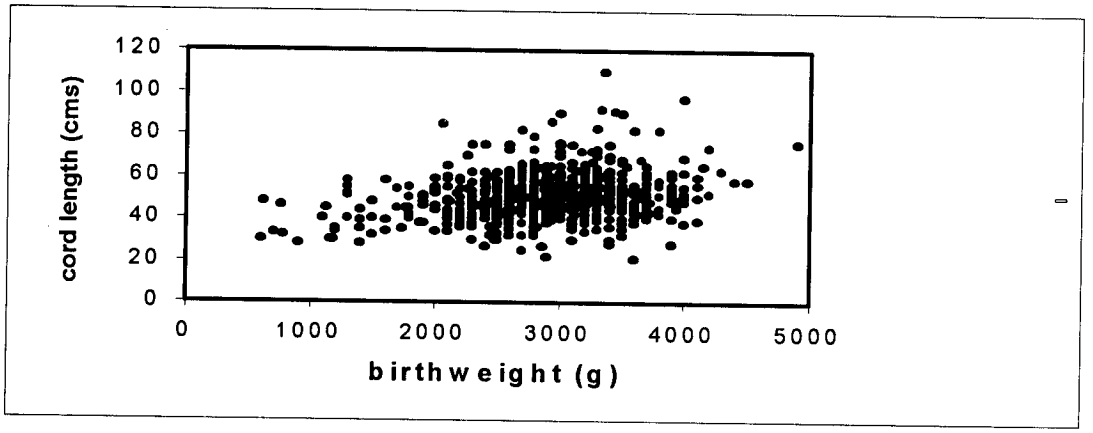
Scattergrams of the relationship between cord length and birthweight

These are presented below in figures 6 and 7 (X and Y axes switched in the 2 scattergrams). Note the wide variation that illustrates what has been described in the previous two tables and figures. The correlation coefficient for birthweight and cord length was 0.24. This reflects a weak positive correlation.

Although the scattergrams are not illustrated, the correlation coefficient for cord length and placental weight was similarly weakly positive at 0.22. The correlation coefficient for birthweight and placental weight was slightly greater at 0.36.

Figures 6 and 7: Scattergrams of cord length and birthweight





Difference in cord length by gender

In order to determine whether there was a gender difference affecting the cord lengths, the mean birthweight, gestation and cord lengths are presented for male and female infants. Although male infants were slightly heavier in this series there was no difference in the gestation and cord length between the sexes (table 14).

Table 14: Difference in cord length by gender of infant (n=916)

	male	female	't' test
N	437	479	-
Birthweight (g)	2986.7	2847.1	.002
Gestation (wks)	38.1	38.1	ns
cord length (cms)	**50.9**	**50.4**	**ns**

Differences in cord length by presentation

The mean cord lengths by presentation are tabulated in table 15 below. The mean cord length of infants delivered as vertex was slightly longer but this difference was not statistically significant.

Table 15: Difference in cord length by presentation of infant (n=916)

	vertex	Breech	't' test
N	854	52	-
cord length (cms)	50.9	50.4	**ns (p=.1)**
Standard deviation	9.9	11.9	

Length of umbilical cord in vertex and breech presentation by gender

In general, there was no statistical difference in cord length when gender, gestation, weights were taken into account. As shown previously in table 15, when taking all infants regardless of gender, there was no difference in cord length between infants of breech and vertex presentation unless gender was also taken into account.

Although numbers of breech deliveries are small, there was a suggestion that cord lengths in the breech were shorter than in infants delivered by vertex presentation. Those male infants delivered as vertex had a longer mean cord length of 51.0 compared to those female infants delivered by the breech who had mean cord length of 46.6 cm (significant, p=0.01). It is noted that male vertex delivered infants were of higher gestation and also heavier. These results are summarized in the table 16 below.

Table 16: Difference in cord length by gender and presentation of infant (n=916)

	vertex	**Breech**	
Male	**51.0 cm**	**49.9 cm**	**ns, p=.31**
	n=407; 38.1wks; 2992.1g	n=30; 37.8wks; 2913.3g	**(vertex vs breech)**
Female	**50.6 cm**	**46.6 cm**	**ns, p=.053**
	n=457; 38.1wks; 2850.2g	n=22; 36.9wks; 2782.7g	**(vertex vs breech)**
	ns, p=.48 (male vs female)	**ns, p=.25 (male vs female)**	

Effect of cord length on outcome in fetuses ≥ 2500g

In order to remove the confounder of prematurity and low birthweight, the outcome was considered in only those infants with birthweight of greater than 2,500g. As illustrated in table 17 the cord length was slightly (but statistically significantly) shorter in those infants of weight greater than 2,500g who were stillborn (46.3 vs 51.8 cm, p=0.02).

In the stillborn group of infants 3 of the 19 (15.8%) were breech deliveries. In the liveborn group 38 of the 721 infants were breech deliveries (5.6%). Furthermore, the birthweight of the stillborn group was slightly (but statistically significantly) less than the liveborn infants. The birthweight and breech presentation could be important confounders to explain the poor outcome in those with shorter umbilical cords.

Table 17: Outcome and cord length of infants > 2,500g (n=740)

	Stillborn	**Liveborn**	
	19 3 breech (15.8%) 16 cephalic	**721** 38 breech (5.6%) 683 cephalic	**'t' test (significance)**
Mean cord length (cm)	**46.3**	**51.8**	p=0.02
Std deviation (cm)	10.5	9.94	
Birthweight (g)	2967.4	3128.7	p=0.02
STD Deviation (g)	301.2	398.8	

The 19 stillborn compared to 721 liveborn in the over 2,500g group represented a stillbirth rate of 2.6%. By contrast of the 176 infants of weight less than 2,500g, 25 were stillborn (rate of 16.6%). Of these the majority were infants of weight less than 2,000g.

Effect of insertions on infant outcome

Table 18 summarises the outcome of all infants in relation to the cord insertion. As pointed out previously there were no infants with a velamentous insertion and only a few who had a marginal insertion. There was no statistical difference in the gestation or cord length of the infants who had one of the three types of insertions. The few infants with a marginal cord insertion were slightly heavier than those who had an eccentric insertion. Apgar scores were comparable as were stillborn by weight category.

Table 18: Outcome and cord length of infants (n=916)

	Central	**Eccentric**	**Marginal**
N	435	463	18
Gestation (SD) (wks)	38.0 (3.5)	38.1 (3.5)	40.9 (2.3)
Cord length (SD) (cms)	50.3 (9.1) cent vs ecc p=.17 (ns)	50.9 (10.8)	52.9 (11.9) ecc vs marg p=.25 ns cent vs marg p=.18 ns
Birthweight (SD) (g)	2938.8 (588.8) cent vs marg p=.11 (ns)	2889.3 (595.6)	3058.3 (397) ecc vs marg p=.05 (sig)
Apgar Score (5 min)	**n (%)**	**n (%)**	**n (%)**
0	19 (4.4)	25 (5.4)	0
1,2,3	1 (0.2)	5 (1.1)	0
4,5,6	4 (0.9)	4 (0.9)	0
7,8	9 (2.1)	13 (2.8)	0
9,10	402 (92.4)	416 (89.8)	18 (100%)
all	**435 (100%)**	**463 (100%)**	**18 (100%)**
Stillbirths	**n (%)**	**n (%)**	**n (%)**
<1500g	6 (31.6)	5 (20)	0
1500-2000g	2 (10.5)	3 (12)	0
2000-2500g	2 (10.5)	7 (28)	0
2500g+	9 (47.4)	10 (40)	0
all	**19 (100%)** **19/435 (4.3%)**	**25(100%)** **25/463 (5.4%)**	**0**

DISCUSSION

From the literature review it was anticipated that there would be a wide range of umbilical cord lengths. The discussion will focus on how umbilical cord lengths in a homogeneous Zambian population compare with those from other parts of the world.

Umbilical cord length

This study shows the wide range of umbilical cord length for Zambian infants delivered at gestation age of 28 weeks to term. The range was from 21 to 110cm. However almost 75% were between 40 and 60 cm in length. The mean length was 50.7cm and most had a length of 50.0 cm (mode) (table 8 and figure 1, page 20). This is in agreement with cord lengths at term of a number of studies from Africa, USA and UK which reported means ranging from 50 to 60 cms and which are summaried below:

Author and Year	**Country**	**Number**	**Gestation**	**Mean cord length**
Abgoola 1978	Nigeria	602	Term	57.4 cm
Walker and Pye 1960	UK	177	28-term	43-56 cm
Adinma 1993	Nigeria	1000	Preterm- term	51.5 cm
Malpas 1964	UK	538	Term	61 cm
Rayburn et al 1981	USA	536	Term	55.0 cm
Naeye 1985	USA	24,000	38-42	57.4 – 59.6 cm
This study	**Zambia**	**916**	**28-term**	**50.7 cm**

Abnormal umbilical cord length (either excessive or shortened) is a known risk factor for adverse perinatal outcome. Long umbilical cords predispose to cord entanglement, prolapse, torsion or thrombosis, whereas short cords predispose the fetus to rupture of the cord, failure to descend in labour, abruption of placenta and have been associated with congenital fetal anomalies such as Pena-Shokeir phenotype (fetal akinesia per hypokinesia sequence) (Collins 1994), breech and other fetal malpresentations.

Gestation

As Walker and Pye (1960) had indicated in 1960, the length of the cord of over 46 cm is considered long enough for a child to be put on the breast with the placenta still in-utero and that the reflex stimulation of suckling may promote an easy and bloodless third stage. They also suggest that cords do not grow substantially in length after 28 weeks gestation. This is corroborated by the findings in this study and presented in table 11 and figure 3 (page 23). Although it appears that the cord lengths at lower gestations are lower and increase with gestation, this is not borne out statistically in view of the wide variation of lengths. Naeye (1985) showed similar findings from 28 to 42 weeks gestation – despite a trend towards it, there was no statistical increase in cord length beyond 28 weeks to term. It is also suggested that this is in keeping with the fact that the placenta also begins to slow down its growth after that time. Mills et al (1983) had also concurred that in the third trimester cord length slows down (but does not completely stop). Adinma in Nigeria (1993) reported similar findings.

Birthweight and placental weight

In addition to considering whether cord length varied with gestation, the relationship with birthweight (table 13 and figure 5, page 25) and with placental weight did not show any obvious relationship. The correlation coefficient in this study for birthweight and cord length was 0.24 while that for cord length and placental weight was 0.22. This agrees with findings of Malpas (1964) that had correlation coefficients of around 0.25 for both. Similarly Agboola in Nigeria (1978) had reported correlation coefficients of 0.22 between cord length and fetal weight and 0.25 between cord length and placental weight. These weak positive correlation coefficients all point to a slight increase in cord length with gestation, birth weight and placental weight but the wide variation renders the association weak.

Sornes (1995) showed that umbilical cord encirclements were associated with fetal growth restriction – the severity of the restriction being positively related to the number of encirclements. Cord encirclements were also associated with a relative lengthening of the cord though no cord encirclements were recorded at UTH

Rayburn et al (1981) in a series of 536 term deliveries showed that cord accidents were more common in the presence of a long cord. In their series the mean was 55cm but with a range of 14-129 cms). They also found inadequate fetal descent and fetal heart rate abnormalities due to compression when a long or short cord was present.

It is suggested that the wide variation in cord length is associated with the autonomic growth of spatially unconditioned fetal blood vessels, which carry on growing in contrast to the contiguous growth within the fetus (Malpas 1964).

Gender

There was no gender difference in cord length in this study although female infants were slightly lighter (see table 14, page 27). This has also been the finding in the studies reported above.

Presentation

Adinma (1993) had demonstrated a trend that cord lengths were highest in cases where there was unstable lie and shorter in cases of breech and transverse lie. Nevertheless these differences were not statistically significant. Although there were no cases of unstable or transverse lie in this series at UTH, the cord length of the cases of breech was slightly shorter than those with a cephalic presentation. This finding was not statistically significant (see table 15, page 27).

Soernes and Bakke (1986) had studied the effect of gender and presentation on cord length and found almost a 4.5 cm difference between means of cord length comparing the male vertex and female breech infants. This is similar in this study (table 16, page 28). They postulate that the association of decreased motor activity found with breech presentation may also have an effect on cord length. The theory being that linear cord growth occurs in response to tensile forces placed on it.

Other parameters

As suggested by Adinma (1993) maternal age and parity were not correlated with cord length. The study from Taiwan (Wu et al, 1996), of 1087 deliveries showed a significant correlation of birthweight with the cord length while other factors like maternal age,

gestational age (>or = 28 weeks), parity, fetal outcomes or intrauterine fetal well being did not show any correlation with cord length.

Umbilical cord length and fetal outcome

To study outcome in relation to cord length it was decided to only concentrate on the infants of greater than 2,500g to eliminate effects of prematurity. Furthermore the study was not powered to look at correlation between cord length and neurological impairment or poor Apgar scores and subsequently only gross poor outcome (stillborn) was studied. The mean cord length of the infants that were stillborn was less than that of infants who were liveborn. However they were also lighter and there were more breech in that group. It could be argued that a smaller cord length had contributed to the breech (or vice versa). Caution is needed in interpreting these results as there can be many other factors contributing to the poor outcome. A short cord length may simply be a marker of other factors (e.g. breech and growth restriction). As Naeye (1985) had reported in a US study, short cord by itself had a poor predictive value of poor neonatal outcome. However taken together with other factors they can be useful in predicting subsequent neurological impairment.

Regarding negative outcome with long cord lengths, there were no instances with the cord having been tightly wound round the neck, or prolapsed or resulted in cord entanglements, cord prolapse or presentation or true knots as had been reported by Adinma (1990).

Umbilical cord insertions

The umbilical cord may have a central, eccentric, marginal (battledore) or velamentous (membranous) insertion. Central and eccentric insertions account for more than 90% of cords and have no clinical importance (Heifetz 1996). Marginal insertions (5 - 7%) may be more susceptible to vessel rupture and has been associated with fetal growth retardation, stillbirth and neonatal death. Incidence of velamentous insertion (1 - 2%) increases with maternal cigarette smoking, advanced age or diabetes mellitus and among multiple births, malformed infants and in vitro fertilization pregnancies (Heifetz 1996).

The incidence of different umbilical cord insertion as found by various authors (as reported by Boyd and Hamilton, 1970) is summarized below expressed as a percentage. In the present series, different insertions were: central 46.0%, eccentric 51.7%, marginal 2.2% and velamentous 0.1% and these are included below.

AME	CENTRAL	ECCENTRIC	MARGINAL	VELAMENTOUS
hiari et al (1895)	3.3	91.2	5.0	0.5
ıordania (1929)	12.5	80.2	6.2	1.1
rone (1961)	25	64	10	1.0
erlach (1962)	28	62.5	8.0	1.5
rone et al (1965)	14.9	65.4	7.9	1.8
uedia (1968)	46.5	48.5	4.1	0.9
orste (1971)	22.8	62.2	14.7	-
gboola (1978)	26.5	62.5	9.2	1.8
ıis series (1998)	**46.0**	**51.7**	**2.2**	**0.1**

The incidence of different umbilical cord insertions found in this Zambian population is almost similar to the figures given by Pluedia's series (1968) and it may therefore be concluded that there is little racial difference. It is quite plausible that in other studies unless the insertion was totally central it was classified as eccentric. This depends on the precision of the observer. Nevertheless central and eccentric umbilical cord insertions are regarded as a normal variation and constituted 97.7% of the present series. Peripheral insertions (marginal and velamentous) which are pathological variations accounted for the remaining 2.3%. It has been suggested that pathological variations result from disturbance of implantation or faulty implantation of the fertilised ovum, which eventually prevents central insertion of the umbilical cord from taking place. Velamentous insertion of the cord has also been considered to have an etiological significance in development of fetal abnormalities, but this has not been observed in the present series. While some authors have found that marginal insertion of umbilical cord is associated with relatively low birthweight (Knaus 1963), this has not been observed in this study.

There was no relationship found between parity and the type of umbilical cord insertion and this supports the findings of previous authors. Similarly no association was observed between the different umbilical cord insertions and variations in placental weight in the present series.

A Finnish study of Heinonen (1996) had evaluated the association between velamentous cord insertion and adverse pregnancy outcomes in singleton pregnancies. This study found a significant correlation between velamentous insertion and low birthweight, (OR. 2.32), small for gestation age infants (OR. = 1.54), preterm delivery (OR. = 2.12), low Apgar score at 1 and 5 minutes (OR.s=1.76 and 2.47 respectively) and abnormal

intrapartum FHR pattern (OR=1.59). There were no velamentous insertions observed in the series at UTH.

Eddleman et al (1992) studied 82 cases of VCI over a 4-year period. This represented a rate of 0.5% of all insertions. Comparing to over 15,000 deliveries they found that VCI cases had more intrapartum complications and lower birthweight than controls. Routine ultrasound had not picked up the cases of velamentous cord insertions and was only identified in the intrapartum period. However they did not believe that failure to detect the cases by ultrasound was a departure from standard of care. In cases of artificial rupture of membranes this may become important.

On the whole as demonstrated in table 18 in page 30, studying gestation, cord length, birthweight, poor Apgar scores or stillbirths, no obvious effects could be determined due to the different insertions. Although there were a few marginal insertions, there were no cases of velamentous insertions found.

Twin pregnancies

This had not been studied at UTH. However two reports suggest that cord lengths in twin pregnancies (or multifetal pregnancies) would be expected to be shorter. This is on the basis of the previously stated hypothesis that cord length is a function of fetal intrauterine activity. If there is some type of intrauterine constraint, the tensile forces on the cord would be diminished and the cord length shorter. This has been applied to breech presentation and is similarly applied to twin pregnancies. Adinma (1993) had found almost a 6-cm shorter cord length in twin pregnancies. Soernes and Bakke (1987) had similarly found an almost 8 cm shorter cord length in twin pregnancies compared to singletons.

CONCLUSIONS

This study has shown that the average umbilical cord length of Zambian infants over 28 weeks gestation is 50.7 cm. (range = 21.0 - 110.0 cm). This was compared with lengths reported in other studies and no racial difference was found. There was a small increase in cord length with increasing gestation beyond 28 weeks to term and also an association with increasing birthweight. However, because of the large variation in cord length this was not statistically significant. It appeared as if infants that were stillborn had a shorter cord length, and more of these infants were delivered by breech and had lower birthweight.

The prevalence of different umbilical cord insertions, central, eccentric, marginal and velamentous, in this study were 46.0%, 51.7%, 2.2% and 0.1% respectively. Considering the central and eccentric as normal, these data were comparable with the findings of studies elsewhere. No perinatal mortality or adverse fetal outcome in this study was attributed to peripheral umbilical cord insertion i.e. marginal and velamentous.

This study has enabled a baseline of cord lengths and insertions to be established for Zambian women.

LIMITATIONS OF THE STUDY

Although the number on infants studied in this study was comparable to those from many other published series, those for determining effects of long cords (e.g. unstable lie, cord entanglements, cord prolapse) and also for poor infant neurological developmental outcomes would require a much larger sample size.

RECOMMENDATIONS

Attention should be paid to cord length and insertion as it may have bearing on assessment of pregnancy outcome. This information would be useful for counseling purposes. Since these measurements are regularly taken, efforts should be made to standardise their measurement and reporting in the case files.

REFERENCES

Adinma JI. Effect of cord entanglement on pregnancy outcomes. Int J Gynaecol Obstet 1990; 32(1): 15-18.

Adinma JI. The Umbilical Cord: a study of 1,000 consecutive deliveries; Int J of Fertility and Menopausal Studies. 1993; 38 (3): 175-9.

Agboola A. Correlates of Human Umbilical cord length. Int J. Gynaecol Obstet. 1978; 16: 238-9.

Agboola A. The significance of the distribution of umbilical cord Insertion Into the chorionic plate. J Obst & Gyn. East Central Africa. 1982; 1: 145-.

Benirschke K. Obstetrically Important lesions of umbilical cord (Review). J of Rep Med. 1994; 39 (4): 262-72.

Boyd J.D. and Hamilton W. J. Fetal blood vessels of the placenta. In the human placenta, Heffer and Sons Ltd, Cambridge, 1970.

College of American Pathologists Conference XIX on the examination of placenta. Arch Pathol Lab Med. 1995; 115: Number 7.

Collins JH. Ultrasound measurement of umbilical cord length , J Ultrasound Med. 1994; 13: 854.

Desilva N. Zygosity and Umbilical Cord Length. J. Reprod Med. 1992; 37: 850 -52

Eddleman KA. Lockwood CJ. Berkowitz GS. Lapinski RH. Berkowitz RL. Clinical significance and sonographic diagnosis of velamentous umbilical cord insertion. American Journal of Perinatology. 1992; 9(2):123-6.

Grbesa D and Durst-Zivkovic B. Neonatal and placental factors in relation to the mode of umbilical cord insertion. Stereological analysis of chorionic villi. European Journal of Physiology. 1996; 431(6 Suppl 2):R205-6.

Heifetz SA. The umbilical cord: Obstetrically Important lesions: Clinical Obstet. & Gynecol. 1996; 39(3):571-87

Heinonen S, Ryynanen M, Kirkinen P, Saarikoski S. Perinatal diagnostic evaluation of velamentous umbilical cord insertion : clinical, Doppler and ultrasonic finding. Obstetrics and Gynecology. 1996; 87 (1): 112-7.

Kaplan GC. Postpartum examination of the placenta. Clinical Obstet. & Gynecol. 1996; 39(3): 535-48.

Knaus, H.H. The weight of the placenta and its forensic significance. Arch Gynak. 1963; 198: 73.

Malpas P. Length of the human umbilical cord at term. Br Med J. 1964; 1: 673-4.

Mills JL, Harley EE, Moessinger AC. Standards for measuring umbilical cord length. Placenta 1983; 4:423.

Molteni RA, Stys SJ, Battaglia FC. Relationship of fetal and placental weight in human beings - fetal : Placenta weight ratios at various gestational ages and birth weight distributions. J Reprod - Med. 1978; 21: 327-334.

Moore K L . The developing human: Clinical oriented embryology, 5th Ed. Philadelphia: WB Saunders, 1995, pp124.

Naeye RL Umbilical cord length: clinical significance. J Pediatrics. 1985; 107: 278-281.

Rayburn WF, Beynen A, Brinkman DL. Umbilical cord length and intrapartum complications. Obstetrics & Gynecology. 1981; 57(4):450-2, 1981.

Shenker L, Reed K, Anderson C, Hauck L. Spark R. Syndrome of camptodactyly, ankyloses, facial anomalies, and pulmonary hypoplasia (Pena-Shokeir syndrome): Obstetrics and ultrasound aspects. Am J Obstet Gynecol. 1985; 152: 303-307.

Soernes T and Bakke T. The length of the human umbilical cord in vertex and breech presentations. Am J Obstet Gynecol. 1986; 154: 1086-7.

Soernes T and Bakke T. The length of the human umbilical cord in twin pregnancies. Am J Obstet Gynecol. 1987; 157; 1229-1300.

Sornes T. Umbilical cord encirclements and fetal growth restriction. Obstetrics & Gynecology. 1995; 86(5):725-8.

Walker CW and Gillian Pye B. The length of the human umbilical cord – a statistical report. BMJ. 1960; 1: 546-548.

Wu JF. Chang SY. Hsu TY. Hsieh CH. Kung FT. Hwang FR. Tsai YC. Tai MC. Chang TC. Chang JC. Changchien CC. Yang LC. Multivariate analyses of the relationship between umbilical cord length and obstetric outcome. Changgeng Yi Xue Za Zhi. 1996; 19(3):247-52.