Length of the Human Umbilical Cord at Term

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This inquiry into the length of the umbilical cord at term was prompted by the delivery of a normal child weighing 7 lb. 8 oz. (3.4 kg.) with an umbilical cord measuring 51 in. (129 cm.), not a unique case, but one which raised the question whether a cord of this length is an exceptional phenomenon, quite outside the normal range, or whether cord lengths form a continuous series with a significant number of instances of intermediate length between the shortest and the longest recorded. The question is important, for if such a series exists the degree of correlation between the length of the cord and various other growth phenomena becomes a legitimate matter for investigation.

Apart from an interesting paper by Walker and Pye (1960) little attention has been shown in this problem. Those workers measured the lengths of the cords of 177 infants born from the 28th week of pregnancy onwards. The histogram of their results showed that the lengths do form a continuous series. The present inquiry differs in that the data were taken from a consecutive series of normal infants born at or near term. A total of 538 cords were measured and recorded with the weights of the foetus and placenta in each case. Fig. 1 shows the frequency distribution of the various lengths.

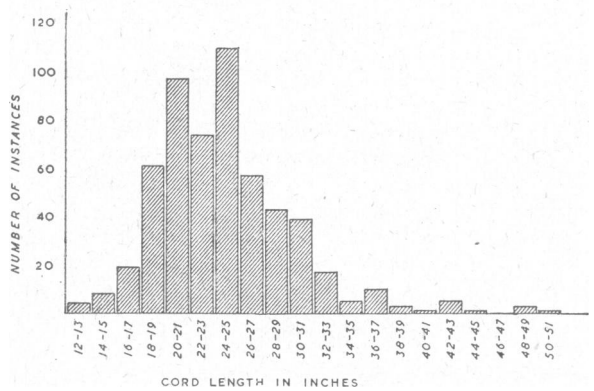

FIG. 1.—Length of 538 normal cords.

The average length of the cords in the series was 24 in. (61 cm.) with a standard deviation of ±4. The histogram, which conforms to that given by Walker and Pye, shows a rapid increase from the minimum of 12 in. (30 cm.) to the peak number of instances at 24 in. (61 cm.), a rapid fall to the 30-in. (76-cm.) mark, and then a slow and fairly uniform decrease to the maximum of 51 in. (129 cm.). Of the cords measured, 85% were 18 to 31 in. (46 to 79 cm.); 6% were less than 18 in. (46 cm.), and 9% were longer than 31 in. (79 cm.). Figs. 2 and 3 present the data in a different way. When plotted logarithmically the graph is a straight line.

Two consequences follow from these results. One has been referred to—namely, that because the lengths can be arranged in a continuous series, a comparison between cord lengths and other indices of foetal growth becomes a legitimate and possible inquiry. The second is that the blood flow in the umbilical vessels and the amount and pressure of the blood entering and leaving the placenta cannot be a function of their length. The point is discussed by Reynolds, Light, Ardran, and Prichard (1952) in an important paper, in which they observe: "Since it was impossible to determine directly the pressure gradient along one umbilical artery, Reynolds (1952) had suggested that there was a pressure gradient of 0.5 to 1 mm. Hg per centimetre of artery, but in light of the present observations on the effects of direct puncture of the umbilical arteries, this view may have to be revised. Certainly the pressure gradient was

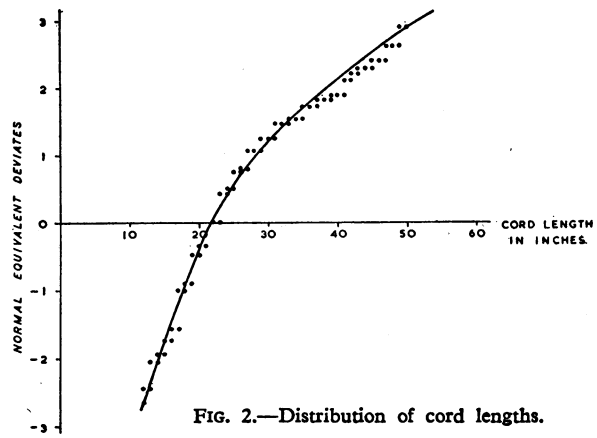

FIG. 2.—Distribution of cord lengths.

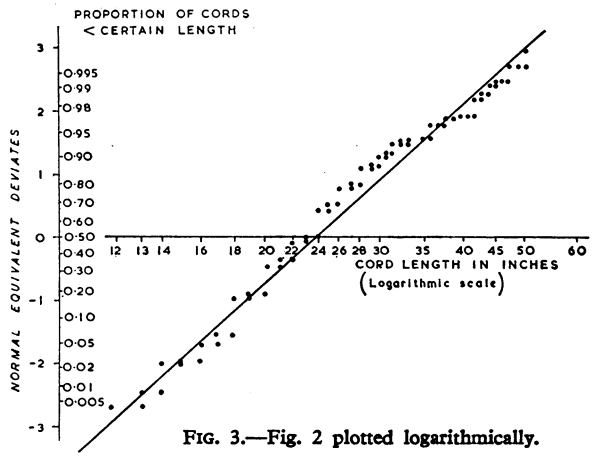

FIG. 3.—Fig. 2 plotted logarithmically.

insufficient to cause any measurable variation in the diameter of the umbilical artery as shown by angiograms of the whole vessel during a complete pressure cycle." Expressed otherwise, the pressure at the placental end of the umbilical arteries is not dependent on their length; for if it were, and if the pressure fall were uniform, the terminal pressure in the umbilical arteries would be too low for normal placental function in the case of the longer cords.

Relation Between Cord Length and Foetal and Placental Weights

Walker and Pye (1960) recorded various linear correlations between cord lengths and certain factors which they surmised might influence the length. In their series they found that it was not influenced by parity, by the age, height, weight, or blood group of the mother, by the weight or sex of the child, or by the incidence of pre-eclamptic toxaemia. In the present series attention was confined to the weights of the foetus and the placenta.

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Correlation coefficients between the various factors were calculated from the 538 sets of data by Mr. Birch, of the department of applied mathematics, University of Liverpool. His results were as follows:

Correlation coefficient between weight of foetus and length of cord	+0.2541
Correlation coefficient between weight of placenta and length of cord	+0.2534
Correlation coefficient between weight of foetus and weight of placenta	+0.6139
Multiple correlation coefficient between weight of foetus and placenta and length of cord	+0.2813

These results denote a partial correspondence between the weight of a foetus and its placenta and a much lower correspondence between the cord length and the other two measures of growth.

Table I shows the average cord length and placental weight in the various foetal weight groups.

TABLE I

Weight of Foetus		Average Length of Cord		Average Weight of Placenta	
oz.	g.	in.	cm.	oz.	g.
<72	<2,040	21 ± 4	53 ± 10	21 ± 4·5	595 ± 127
104 or over	2,950+	27 ± 4	69 ± 10	23 ± 4·7	652 ± 133
152 or over	4,310+	28 ± 4	71 ± 10	33 ± 7	935 ± 198
160 or over	4,535+	28·8 ± 7	73 ± 18	36 ± 8	1,020 ± 227

With normal material every departure from the average is significant. Expressed otherwise, a negative instance has a force equal to and perhaps greater than an instance which conforms to the mean. Thus of the 10 cases in which the foetus weighed more than 10 lb. (4.5 kg.) the cord of one measured only 18 in. (46 cm.) and of another only 16 in. (41 cm.) At the other end of the foetal weight range, of the 40 cases in which the foetus weighed less than 5 lb. 12 oz. (2.6 kg.), the accepted level of mature weight, in 10 the cord measured 24 in. (61 cm.) and in one case as much as 36 in. (91 cm.).

One interesting point emerges from this table. In the underweight group the average length was 21 in. (53 cm.) with a standard deviation of ±4 (10), as compared with an average for the whole series of 24 in. (61 cm.), suggesting that the cord tends to attain most of its length in the earlier stages of foetal growth and giving partial support to Walker and Pye's conclusion that "there is no evidence of growth in the cord length after the 28th week of pregnancy," or perhaps rather that the rate of growth of the cord tends to fall away after the 28th or 30th week, in contrast to the continued and increasing rate of growth of the foetus itself up to term.

Cord Lengths of Uniovular Twins

Further to examine the relation between the various factors, a series of 37 pairs of uniovular twins were examined. The data are shown in Table II. The series was useful in that it contained a high proportion of premature births. The tendency of cord growth to slow down in the last weeks of pregnancy is again exemplified. In 16 instances the smaller twin had the longer cord. Of the 21 cases in which the cords of each pair were equal or within an inch of each other the weights of the infants showed no such correspondence. In this group the average weight of the smaller twin was 65 oz. (1,840 g.), of the larger 75 oz. (2,125 g.).

TABLE II.—*Uniovular Twins*

Maturity (Weeks)	No. of Pairs	Average length of Cord	
		in.	cm.
25	1	14	36
28	1	18	46
29	1	17	43
30	1	21	53
31	1	20	51
32	—	—	—
33	1	17	43
34	1	19	48
35	4	19	48
36	3	21	53
37	3	19	48
38	8	21	53
39	6	20	51
40	5	25	63
41	1	21	53

Discussion

Briefly, the series does establish that there is a wide range in the length of the cord compatible with normal foetal growth and that the average length, 24 in. (61 cm.) in the series, denotes, not the normal length, using the term in its strict sense, but merely that length which occurs most frequently. And, further, that there is an incomplete correspondence between the length of the cord and the two main indices of embryonic growth—namely, the weight of the foetus and of the placenta. Although superficially this finding may seem inconclusive, as were also those reached by Walker and Pye (1960), its very negative character is significant. It suggests that foetal blood-vessels, when they grow in one dimension and independent of contiguous structures, do so in an autonomic manner; in other words, that the cord is an example of unconditioned vessel-growth. The unique nature of the umbilical arteries is further instanced by the presence of the nodes of Hoboken, those crescentic folds of the intima seen in the human umbilical arteries, and, according to Reynolds (1952), in no other vessels. Within the body of the foetus, organs are shaped by a mutual three-dimensional restraint between the cells of each organ and its vascular framework. In the placenta, too, blood-vessel growth is still restrained, as is shown by the greater correspondence between foetal and placental weights than between foetal weight and cord length, although the fact that the correspondence is far from complete shows that placental growth, a growth which is largely that of blood-vessels, is still partially autonomic. The autonomic growth of spatially unconditioned foetal blood-vessels may have some bearing on the origin of certain foetal malformations, in many of which there is a failure of harmony between the foetal cells and their vascular framework, the common angiomata for instance, or perhaps anencephaly, in which the foetal brain is replaced by an amorphous mass of blood-vessels.

Summary

The length of the normal umbilical cord at term has a wide range. A total of 538 normal cords, when measured and tabulated, formed a continuous series with a peak number of instances at 24 in. (61 cm.), the curve falling gradually to the maximum of 51 in. (129 cm.) recorded. In other words, long cords are not special events, but terminal members of a normal range, and, as such, are to be interpreted in the context of those factors which determine foetal growth in general. But very little correspondence was found between the length and the foetal or placental weight of each child. This negative finding shows that foetal blood-vessels, when unconditioned spatially by contiguous tissues, grow in an autonomic way, in contrast to their growth within the foetus, in which tissues are shaped by interaction between the cells of an organ and its vascular framework. In some foetal malformations there is evidence that the initial lesion may be an unconditioned growth of blood-vessels akin to that obtaining in the normal cord.

The data in this series were ascertained by Miss Davies, labour ward superintendent, of the Liverpool Maternity Hospital, and by Miss Stewart, midwifery superintendent of Whiston Hospital.

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