MORPHOLOGICAL AND VASCULAR PATTERN OF THE HUMAN PLACENTA AND UMBILICAL CORD IN NORMAL AND ABNORMAL PREGNANCIES

by

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Introduction

The study of the vascular pattern of placenta has been undertaken by several workers since the early parts of the nineteenth century, but controversy still exists regarding the exact vascularisation. Most of the literature available on this subject deals with the vascular pattern of placenta only in normal cases.

The present study was undertaken to find out whether any difference in the morphological and vascular pattern existed between the placentae from normal cases and those from such cases as were complicated by conditions like toxaemia of pregnancy, diabetes, stillbirth, etc., which might have caused placental insufficiency, and also whether any particular morphological and vascular anomaly could be held responsible for giving rise to any particular clinical conditions like congenital anomalies or intrauterine death.

Bumm (1893) worked for more than 10 years on the vascular pattern of the placenta.

Baesich and Smout (1938), Spanner (1935), Reed (1951), Wilkin (1959), Tompsett (1959), Arts (1961) and Crawford (1962) used the injection corrosion technique for preparing three dimensional casts of placental blood vessels. They injected coloured solubea of gelatin latex with subsequent corrosion.

Certain workers Shah (1964), Youseff (1966) and Nawal Kishore (1967) have carried out a postpartum radiological study of the vascular pattern of placenta by injecting radio-opaque material in the umbilical vessels in order to eliminate the possibility of artefacts occasionally produced in the injecton corrosion technique.

Material and Methods

We have in this series used the injection corrosion technique as well as placentographic study by the injection of 10 per cent barium Sulfate.

Placentae were collected from the labour room immediately after delivery. No preservative was used. Each placenta was kept in fresh tap water with the maternal surface upwards. Gross features of the placentae and umbilical cords were studied including their weight, shape, thickness, diameter, number of cotyledons, attachment of membranes, length of

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cord and mode of cord attachment. Close study was made to exclude knots and loops of the cord, arterio-arterial or arterio-venous anastomosis, aneurysms and subchorionic extravasations.

Preparation of Cast by the Injection Corrosion Technique:

After washing the placenta for two to three hours in running tap water to remove all blood, it was irrigated with 3.8% solution of sodium citrate for one hour to remove all clots from the lumina of blood vessels. The placenta was again washed in running tap water for about half to one hour to remove the traces of sodium citrate. It was then placed upside down to render it suitable for injection. Red and blue plastic materials were used for injecting veins and arteries respectively. After the injection of the plastic material the placenta was allowed to stand for 30 minutes in order to permit the plastic material to set in the vessels. The placenta was then placed in a porcelain desicator or on a glass plate and dipped into concentrated hydrochloric acid contained in a glass trough.

About 2 to 22 hours were required for corrosion of the placenta. The placenta was removed from the trough by glass rods and washed under a fine shower of water. When all the corroded material was removed the cast was left in a tray under running tap water for three to six hours, to remove all traces of the acid. The cast was then transferred to a trough containing equal volumes of formaline and glycerine for 12 hours. Finally, the cast was preserved.

Placentograms were taken in 66 cases by injecting barium into the vascular tree.

The placenta was washed thoroughly with water. After the water was removed as described above 10% barium sulphate was injected in one of the umbilical arteries about three inches above the insertion of the cord. When the whole vascular tree was filled with the solution the injection was discontinued and the artery was tied. The placenta was washed again to remove the barium spill, if any, and a X-ray was taken with an exposure of four KV x 16, and the areas of defective filling and vascularity were studied in the films thus taken.

The gross morphology of 250 placentae was studied, out of which 160 casts were made by the injection corrosion technique, in 66 placentograms were taken, while the remaining 24 had to be discarded as the vessels ruptured during injection.

A full clinical history was taken, as well as the examination and relevant investigations of the mothers, concerned were done. The placentae were from the following clinical conditions :—

Observations

The following conclusions were drawn from the morphological study of the placentae:—

1. Age and parity of the mother did not affect the morphological or vascular pattern of the placentae nor the ratio of foetal placental weight.

2. Four out of 250 (1.6 per cent) placentae were circumvallate (Fig. 1). Two of the circumvallate placentae were associated with stillbirths and single umbilical artery—one of these stillborns being congenitally deformed. The other two mothers giving birth to circumvallate placentae had mild pre-eclamptic toxaemia but had normal live babies at term.

The incidence of stillbirths associated with circumvallate placentae reported by other authors is as follows. (Table II).

3. Three out of 250 (1.2 per cent) were succenturiate placentae (Fig. Two).

TABLE I

S. No.	Type of cases	No. of cases	
1.	Normal cases	40	
2.	Congenital anomalies	15	(2 cases included with hydramnics)
3.	Stillbirths (including missed abortion)	39	
4.	Preeclampsia	34	
5.	Eclampsia	9	
6.	Toxaemia with accidental antepartum haemorrhage	2	
7.	Hypertension	1	
8.	Diabetes	7	(1 case with hydramnios).
9.	Anaemias	11	
10.	Hydramnios	7	
11.	Twins	52	
12.	Triplets	12	
13.	Rh negative	6	
14.	Postmaturity	4	
15.	Prematurity	10	
16.	Miscellaneous (foetal distress, hepatic coma, placenta praevia, cord round the neck	4	
17.	Mitral stenosis with congestive heart failure	2	

TABLE II

S. No.	Name of Authors		Percentage of stillbirth	Remarks
*1.	Paalman	1953	19.5%	None of these were associated with congenital anomalies
2.	Pinkerton	1956	61.5%	
5.	Scott	1960	53.8%	
4.	Ziel	1963	7.6%	
5.	Wentworth	1968	1.6%	
6.	Present series	1969	50.0%*	

* Two out of four of these had congenital malformation.

None of these were associated with postpartum haemorrhage. One of them was from a normal mother with a live baby born at term. The second was from a hypertensive mother, but the baby was born at term. The third one was associated with a baby born at term having imperforate anus, who died after a few gasps—postmortem was not available to rule out other congenital anomalies.

Robert (1967) emphasized the significance of succenturiate placenta in causing antepartum and postpartum haemorrhage due to low implantation and vasa praevia.

4. An unusually long cord was seen in 10 (four per cent) cases 70-93 cms. None of them was associated with cord prolapse. Nine of these cases with long cord had live births while only one was a stillbirth due to multiple congenital anomalies.

5. Loops in the cord were present in 42 cases (16.8 per cent). Thirteen out of these 42 (30.9 per cent had stillbirth (nine full term and four premature stillbirths). Three of these stillbirths were associated with severe toxaemia and two with severe anaemia which might have caused the stillbirth in the five cases. The remaining eight stillbirths had no other anomaly besides loop in the cord. Shui and Eastman (1957) after examining 1000 cords stated that looping of the cord was an over-rated cause of perinatal mortality.

6. Two cases of true knot were seen in the present series of 250 placentae (0.80 per cent). Both had live births. The

incidence of true knots quoted by Wentworth (1965) was (0.46 per cent) while Spallacy *et al* (1966) quoted an incidence of 1.1 per cent. They reported six per cent perinatal mortality due to true knots.

7. The commonest mode of cord attachment was eccentric in 173 (69.2 per cent) cases, central in 51 (20.4 per cent) and marginal in 26 (10.4 per cent) cases. Williams (1927) and Roberts (1967) reported that nearly three fourths of placentae had eccentric attachment of the cord, the rest had central marginal and velamentous attachments.

8. Umbilical vessels in the cord were arranged spirally in all the cases.

9. A single umbilical artery was present in 12 out of 250 (4.8 per cent) placentae (Fig. 3). The incidence of single umbilical artery reported by Benirscheke and Bourne (1960) as (0.1 per cent); Little (1961) as (4.7 per cent); Wentworth (1965) as 0.8 per cent and Bhargava (1966) as 6 per cent. Four out of 12 (33.33 per cent) of our cases of single umbilical artery were associated with gross multiple congenital malformations. One of these congenitally deformed babies, was stillborn and the other three died within 24 hours (having meningocele, spina bifida, pelvic deformity and shortening of limbs.

Three other cases of single umbilical artery were associated with stillbirths, (two premature stillbirths) and one fresh full term stillbirth. The eighth case of single umbilical artery was associated with missed abortion. The ninth case was associated with premature but live birth. The mother had an associated severe preeclampsia. Benirscheke and Brown (1955) reported associated severe preeclamptic toxaemia in 30 per cent of their cases of single umbilical artery but Little (1961) and Wentworth (1965) did not find any toxaemia in their cases of single umbilical artery. The last three cases (25 per cent) of single umbilical artery were associated with full term normal births.

Benirscheke and Brown (1955) reported that only 10 babies out of their 55 cases (18 per cent) of single umbilical artery were normal. Little (1961) reported (26.2 per cent) incidence of congenital anomalies in their cases of single umbilical artery. They also reported a high incidence of placental anomalies, circumvallate or circummarginate placentae in 39 per cent of their cases of single umbilical artery.

Two of these 12 cases (16.66 per cent) with single umbilical artery had circumvallate placentae in addition, whereas the incidence of circumvallate placenta out of the total 250 placentae studied was only 4 (1.6 per cent).

Study of the Vascular Pattern

1. One hundred and fourty six out of 160 cases (81 per cent) had well marked Hyrtle's anastomosis, that is transverse communication between the two umbilical arteries as they entered the placenta. This anastomosis was first described by Hyrtle (1870) and Schordania (1929). Nine of these 160 cases had a single umbilical artery, hence there was no question of Hyrtle's anastomosis.

In five cases Hyrtle's anastomosis was absent, with two livebirths at term. The third with absent Hyrtle's anastomosis was associated with stillbirth. The remaining two belonged to cases of triplets. In both, the babies being premature though live born.

Wentworth (1965) reported absence of Hyrtle's anastomosis in 2.4 per cent of their cases without any ill effect to the foetus except in one case where it was associated with a macerated stillbirth.

2. The umbilical arteries were found to undergo a dichotomous division rapidly diminishing in size in 207 of 250 placentae (82.8 per cent). This was described as 'dispersed' type of branching of Bascich and Smout (1938) (Fig. 4).

3. The magistral pattern of branching as described by Baesich and Smout was that the main arteries give off smaller branches and almost reach the placental margin before there is marked reduction in size. It was seen in forty placentae (16.0 per cent) (Fig. 5) whereas three of the 66 placentae studied by placentography showed a magistral pattern of branching with a third tributory branch as described by Youseff (1966).

5. The vessels perforated the chorionic plate in a slanting manner before becoming the vascular tree of the cotyledons.

6. They showed branching divisions of the third to fifth orders in most of the cases whereas the range of branching varied from first to sixth order.

7. The vessels in the cotyledons were seen to arise in three ways:—

(i) By deep direct branching.
(ii) By superficial branching.
(iii) By branches directly from the vessels supplying the cotyledons.

The same distribution of the vessels was reported by Crawford (1956).

8. Arterio-Venous anastomosis was seen only in one cast out of 160. The anastomotic channel was four mm. in length. The placenta belonged to a toxaemic mother but the baby was healthy and born at term.

Boe (1954), Arts (1961), Crawford (1962) and Smart (1962) failed to find the existance of any communication between arteries and veins, while Wentworth (1968) reported the existance of arterio-venous anastomosis in chorionic vessels without affecting the babies.

9. In none of our casts, spirals, an eurysms or subchorionic extravasation were seen. Wentworth (1965) reported an incidence of aneurysm as 1.95 per cent.

10. Out of the total 250 placentae studied, 26 pairs were from twins and 4

TABLE III.

Showing mode of cord attachment, pattern of arterial branching and average baby-weight

S. No.	Pattern of arterial branching	Total number	Mode of attachment			Average baby weight
			Eccentric	Central	Marginal	
1.	Dispersed	207	140–67.63%	45–21.73	22–10.63	2.44 Kg.
2.	Magistral	40	31–77.5%	5–12.5	4–10%	2.42 Kg.
3.	Magistral 3rd tributory branch ..	3	2–66.66%	1–33.33		2.26 Kg.

Schrodania (1935) put forward a theory that magistral pattern of branching produced a better developed foetus because its arteries were larger, but this contention was denied by Crawford (1962). In our series we could not find any definite correlation between the arterial pattern and incidence of complicated pregnancies or of birth weights of babies.

4. Out of the 160 casts, arteries crossed over the viens in 153 (96.2 per cent) and only in seven (3.8 per cent) the veins crossed over the artery. Arts (1961) reported that chorionic arteries extend across the veins with a few exceptions, whereas Wentworth reported the incidence of veins crossing the arteries as 31 per cent.

from triplets. Out of these, 9 cases were associated with toxaemia and 7 were of anaemia, the rest of them were normal. Out of four triplets two cases were associated with anaemia and one case with toxaemia.

Out of 26 twins, two were monochorial and the remaining 24 were dichorial. Twelve of these dichorial twins had fused maternal surfaces and the diagnosis of their being dichorial was made by counting the membranes. One case of triplets had monochorial placenta (Fig. 6) in the rest three, the placentae were separate.

(1950), Benirschke (1961), Wentworth (1965) and Bleish (1965) reported anastomosis between monochorial twin placentae as a rule in all cases.

In the placentograms of 66 placentae the radiological grading of vascularity was done as reported by Shah (1964) and Kishore (1967) by marking out and calculating the total area of vascularity.

Grade 'A':— More than two third of the placenta was functioning.

Grade 'B':— Functioning area of placenta between two third and one third.

Grade 'C':— Functioning placental less than one third.

TABLE IV.

Showing the degree of vascularity encountered in the 20 normal cases and 46 abnormal cases

Cases	Grade 'A'		Grade 'B'		Grade 'C'	
	Dispersed	magistral	Dispersed	magistral	Dispersed	magistral
Normal	16	4	—	—	—	—
Abnormal	14	4	16	2	10	—

In the shape and size of the placentae encountered there was nothing abnormal. The arrangement of the vessels was spiral in all the cases. Cord length and the cord attachment do not deserve any special mention.

Hyrtle's anastomosis was present in all the cases except in one case of twins, while, it was absent in two cases of triplets where both the babies were premature weighing 1.589 Kg. each and both expired on the second and third day after delivery respectively and the cause of death being prematurity.

All the three cases (twins and triplets) of monochorial placentae had well marked arterio-arterial anastomosis. Veno-venous anastomosis was seen only in two cases. Both, presence and absence of the arterio-arterial or veno-venous anastomosis was seen in the dichorial placentae.

Hyrtl (1870), Schatz (1884), Prince

The degree of vascularity of the placentae could not be correlated with the clinical severity of toxaemia and other conditions. Two cases of eclampsia showed grade 'A' vascularity whereas two cases of moderate preeclamptic toxaemia had grade 'B'. Placental vascularity was markedly diminished only in cases of macerated stillbirths, four placentae from fresh stillbirth due to severe anaemia showed grade 'A' vascularity.

Summary

1. There was no correlation between the distribution of blood vessels and baby weight.

2. Vascularity of the placentae was markedly diminished only in macerated stillbirths.

3. The vascularity of the placenta was not affected by the degree of toxaemia.

4. No particular vascular pattern or

distribution could be correlated with any particular clinical condition except in cases associated with single umbilical artery.

5. Single umbilical artery was associated with congenital anomalies in 33.33 per cent and stillbirths and missed abortions in another 33.33 per cent the remaining were normal.

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See Figs. on Art Paper I and II