

## On the Abnormalities of the Umbilical Cord which may cause Antenatal Death.

By

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### TRUE KNOTS ON THE CORD.

The occurrence of true knots on the umbilical cord must be looked upon as somewhat rare. According to Von Winckel they are present in 0.4 per cent. to 0.5 per cent. of all births, while Chantreuil states that out of 6,075 deliveries observed in the Hôpital des Cliniques, Paris, seven knots were found, six simple and one double, *i.e.*, about one in 1,000 deliveries. v. Hecker records 31,590 births in which true knots occurred 115 times, or once in 274 cases, and in no case was the child injured. In the great majority of cases in which true knots are present they are comparatively slack and have no effect upon the development or life of the foetus. Indeed, the opinion has been frequently expressed that they can never be drawn sufficiently tight before labour to obstruct the circulation in the cord and thus be a cause of foetal death. Baudelocque was one of the chief exponents of this view and stated that in some cases he had found even two knots present and the foetus alive and as large as usual. In one interesting case which he figures, the cord was three times knotted, one knot being interlaced in the other, and still the child was born alive and healthy. The knot was situated about a foot from the umbilicus and was drawn "as tight as any knot could be in such a case." Baudelocque the younger reported three cases of cord knots in two of which the knots were double and were so tight that they left, at the part of the cord where they were situated, a deep furrow-like depression, and yet the infants were born alive and well. Gardien says "when the umbilical cord is very long, it may become entwined around the child's neck and may even form knots; they can never tighten themselves during the pregnancy sufficiently to cause the death of the foetus or interfere with its growth."

Chantreuil, on the other hand, thinks that they may be a cause of intrauterine death, and that even though born alive the child may be thin and ill-nourished. Levret says: "One sometimes

finds the umbilical cord knotted in a true knot, it is sometimes twisted so as to be doubled, or it may occasionally be even separated from the placenta; when one of these three circumstances occurs the foetus usually perishes before term or it is at least much emaciated."

Jacquemier says: "The knots that the foetus forms in passing through a loop of cord appear rarely to block the circulation. It is, however, possible that the foetal movements can tighten a knot sufficiently to block the circulation, but it is difficult to bring forward convincing examples of death caused in this way."

Naegele and Grenser state that while knots arising during pregnancy are usually harmless, some facts seem to demonstrate that they may exceptionally block the circulation of the cord and thus cause atrophy and death of the foetus; "One has often met with these knots on an umbilical cord of foetuses born macerated, but it will always be uncertain if in these cases the knots were not tightened only after death of the foetus."

Smellie, describing a case of foetal death which he attributes to a knot on the cord, says: "If the navel string be long and the quantity of surrounding waters great, the foetus, while young, may, in swimming, form a noose of the funis through which, should the whole foetus pass, a knot will be formed on the navel string which, if tightly drawn, will absolutely obstruct the circulation."

Tarnier made a knot on a cord and pulled it as tight as possible, then injected fluid, and always found that the fluid could pass. He found that when the vessels proximal to the knot swelled up with fluid the knot partly untied itself, and he thinks the same would happen by the foetal heart pumping the blood through the umbilical vessels. It was only on putting three knots on the cord as closely together as possible that any resistance was experienced. This, it may be said in passing, appears to be an altogether unjustifiable conclusion, for no statement is given concerning the pressure at which the injection was made or evidence adduced that it was not many times greater than that propelling the blood through the vessels of the cord. Lefour and Oui more recently showed that the slight weight of 25 to 90 grms. attached to the cord sufficed to tighten a slack knot sufficiently to cut off an artificial circulation in the cord. These observations are in accordance with my own findings, which are briefly as follows:—

An umbilical cord was taken an hour after delivery and separated from the placenta. A glass canula was fitted into the vein, while to the other end of the canula was fixed a long rubber tube connected with a mercury manometer.

Through the open end of the tube water was injected by means of a large Record syringe. During the experiments the surface of

the cord was kept well lubricated with vaseline in order that its slippery surface might as nearly as possible resemble that present during intra-uterine life.

It was found that when there was no knot on the cord the fluid passed through it at a pressure of 10 mm. of mercury.

When one slack knot was put on the cord and no weight attached, and the knot not in any way tightened, the fluid passed through at a pressure of 20 mm. Even the slackest knot, therefore, caused some obstruction, and this was made evident by the visible swelling and engorgement of the cord on the proximal side of the knot. Next the strands of cord involved in the knot became engorged and finally the fluid passed, the knot becoming partly opened out at the same time.

When two true knots were formed, one superimposed on the other, the fluid passed at a pressure of 60 mm.

A single true knot was placed in the cord, and a weight of 20 grms. was tied to its distal end. No attempt was made to tighten the knot except by the weight attached to the end. The fluid passed at a pressure of 40 mm.

With a weight of 50 grms. a pressure of 70 mm. was required.

With a weight of 100 grms. a pressure of 100—110 mm. was required.

With a weight of 140 grms., 140—150 mm. was necessary.

With a weight of 160 grms. fluid failed to pass at a pressure of 165—170 mm.

The arterial pressure in the umbilical cord varies from 39.3 to 83.7 mm., while the venous pressure is about 16 mm. (Feldman).

These experiments show that even a slack knot may be sufficient to interfere with, if not completely to obstruct, the cord circulation, but that any pull upon the knot such as might be exerted if the cord were wound around the child's neck or body so as to cause a relative shortening of it, would easily cause sufficient tightening to impede the circulation completely.

*Mode of Formation.* The chief causes which predispose to the formation of knots appear to be: (1) undue length of the cord; (2) hydramnios; and (3) exaggerated foetal movements; while by some the occurrence has been attributed to violent movement on the part of the mother (Guterman), followed by tumultuous foetal movements which afterwards immediately and permanently ceased. While abnormal length of the cord appears to predispose, instances are not wanting in which a true knot was found upon an exceedingly short cord. Thus in the case of Collyns the cord was only six inches long and had two knots, the foetus being almost in contact

with the placenta. In the case of Woets the knotted cord was only 14 inches long. Abundance of liquor amnii will obviously facilitate foetal movements and thus favour knot formation. Schneider held that the knots cannot be formed by foetal movements but are pre-existing and of developmental origin. This opinion is not generally held, the usual view being that the foetus swimming in the liquor amnii passes accidentally through a noose of the cord. If it passes only partially through the noose a coil is formed around the neck or body. If, before passing through the loop, it first passes under the cord and then over the adjacent limb of the noose, or if it first twists itself around the placental end of the cord, a complicated knot is formed. If the loop is double when it passes through, *i.e.* contains two strands in its whole circumference, a figure of eight knot results. During labour a true knot may result from the foetus passing through a loop spread out in the lower uterine segment. It is obvious that the formation of a knot leads to some shortening of the cord. This of itself may, if the cord is unduly short to start with, lead to the tightening of the knot by the mere weight or movements of the foetus, but tightening is more likely to occur if in addition the cord is wound round the neck, body or limbs. The mere movements of the foetus may then suffice to tighten the knot. In this connection it is of interest to note that in a number of the cases in which death of the foetus was attributed to a knot on the cord it is recorded that the latter was wound once or twice around the body or neck. It is probable that a slight interference with the circulation produced by a comparatively slack knot may lead to such violent foetal movements that the knot may be tightened sufficiently to cause complete obstruction.

Van Swieten, quoted by Naegele and Grenser, reports the case of a woman who, in two successive pregnancies, gave birth to a dead foetus, and each time there was a very tightly drawn knot on the cord.

According to Chantreuil, the formation of knots is most likely to occur between the ninth and twelfth week when the foetus is small and the movements free owing to the relatively large amount of liquor amnii.

According to Hyrtl, the time of formation of the knot may be in some degree indicated by its situation. Thus, if close to the navel, it was probably formed at an early period of pregnancy. It must be noted, however, as pointed out by Chantreuil, that considering the slippery surface of the cord and the slackness of the knot immediately after its formation, it is not inconceivable that it might slide in one or other direction. This is a fact that may be easily verified by anyone. During the injection experi-

ments detailed above, I found that the engorgement and swelling of the cord from accumulation of fluid behind the knot was frequently sufficient in itself to shift the knot downwards from two to six inches.

*Anatomical Changes in the Cord.* Here it is necessary to make a distinction between old and recent knots. In the latter, which are usually formed during labour, there are no anatomical changes, excepting possibly some œdema on the foetal side of the cord. In old knots, on the other hand, in which the knot has been drawn sufficiently tight to obstruct the circulation, there are usually well marked changes which may be described as follows:—

(1) There is marked and permanent grooving of the cord at the site of the knot, by the loops forming it.

(2) At the compressed parts of the knot there is more or less complete disappearance of the jelly of Wharton, and all the portions of the cord entering into the knot may be flat and band-like.

(3) When the knot is undone there is persistent curling of the cord at the part where the knot formerly existed.

(4) The vessels in the knotted part are compressed and their calibre diminished while, as in the case of Holzapfel (*vide infra*), the vessels in the proximal part of the cord may have their walls thickened by increase of the fibrous and muscular tissue due, possibly, to hypertrophy of their coats. In some of the recorded cases, after undoing the knot, the vessels were found to be impervious to injection.

(5) That portion of cord between the foetus and knot (the proximal part) may be œdematous while the distant part may be thin and pale, as in Holzapfel's case, and the cases of Canivet and Hannay. In Veit's case, on the other hand, and in that of Bonnaire and Schwab, it was the placental end of the cord that appears to have been swollen, while in the last mentioned case the placenta also was œdematous.

(6) In six out of 23 cases which I have collected from the literature it is recorded that the cord was looped round the neck, and in one of these it surrounded it three times; in another it so tightly compressed the soft tissues of the neck against the vertebral column that the foetus was almost decapitated.

*Signs and Symptoms.* In most cases the only symptom present is cessation, usually sudden, of the foetal movements. Sometimes this has been preceded by undue activity of the foetus. When this occurs it is probably to be looked upon as due to gradual asphyxiation of the foetus from tightening of a knot previously formed and not as the cause of knot formation. It is recorded in nine out of 24 cases tabulated below. In three cases it is specifically stated that the movements ceased gradually. As the cessation of

foetal movement coincides with foetal death, the uterus ceases to develop and the abdomen to increase in size. In short, all the signs of foetal death will gradually become apparent. My own experience of true knots in the case of dead foetuses is limited to two cases. I have, besides, twice seen true knots on the cords of infants born alive and healthy. In neither of these cases, however, was the knot at all tight.

Case 1. Three-para, aged 31, previous three children alive and healthy, the youngest aged two. The mother had always been healthy and the present pregnancy was normal until three weeks before delivery, when foetal movements ceased to be felt. Apparently, no other symptoms had been noticed. The patient was confined at her own home, where the foetus was born before arrival of the nurses. It was a premature macerated foetus, 1215 grms. in weight and 42 cm. long, and judging from the degree of maceration, had apparently been dead about the period during which no movements had been noticed, *viz.*, three weeks. The liver weighed 33 grms., spleen 1.5 grms., placenta 152 grms., small and pale and showing no hæmorrhage nor pathological infarction; cord 60 cm. long and at the middle showed a simple true knot which was very tightly drawn but easily undone. There was no history leading one to suspect the presence of syphilis. Spirochaetes were absent from the foetal organs, and in the absence of any other demonstrable cause of death it seems probable, although unproven, that the knot was the cause.

Case 2. One-para aged 18, healthy and married over two years; first child alive and well, aged 14 months. The father, also, so far as could be ascertained was healthy. Labour was precipitate at full time, a male child being born alive and well, followed by an acardiac foetus and the placenta, before arrival of the midwife. The living child had a slight deformity of one thumb which was flail-like on account of congenital absence of the metacarpal bone. The acardiac foetus was sent to me with the placenta and the above history by Dr. Allan Rutherford, Barrow-in-Furness. The acardiac foetus was badly macerated (papyraceous), and was represented by two lower limbs of fairly normal appearance, a pelvis, and a badly formed abdomen, to the upper margin of which there was attached a rudimentary upper limb. The umbilicus was represented by a slightly elevated papilla, partly surrounded by a furrow at the lower margin of attachment of the upper extremity; (a full description of the specimen will be found in the Trans. Edin. Obst. Soc. 10th May, 1923.)

The umbilical cord of the acardiac foetus joined the cord of the other foetus one inch from its root. There seemed to be an anastomosis between the vein in the cord of the normal foetus and that of the cord of the acardiac foetus, in the last inch of common cord.

In the cord of the acardiac foetus there seemed to be no abnormality on microscopic examination, there being present two arteries and one vein. In the root of the cord, however, and close to the abdomen, there was a sac which contained a few coils of intestine. About one inch distal to this there was a true knot on the cord, very tightly drawn, which may have been the cause of foetal death. In such a monster as this, however, there is sufficient cause of death present without invoking any other; the most interesting feature in the case is that it is impossible to conceive of such a headless and almost limbless monstrosity indulging in active movements, so that the latter seem to be somewhat discounted as an important cause of the formation of cord knots. The circulation in the acardiac foetus was probably carried on by means of the heart of the normal foetus which drove a certain quantity of pure venous blood through the cord of the former to the rudimentary limbs, whence by *vis a tergo* it was returned through the two small umbilical arteries into the common placental circulation. The two placental circulations must, therefore, necessarily have communicated, possibly in the common part of the cord.

*Knotted Cords in Monamniotic Twins.* Several cases have been recorded in which in monamniotic twins the cords were knotted together or otherwise entangled, usually leading to death of one or both. In Pallin's case, however, the children, which were born at the eighth month with their cords knotted together, lived two and three days respectively. In Lindsay's case the cords were in actual contact at their origin and were twisted around one another and tied in a knot; both twins were dead born and macerated. Jeannin reported a case in which the cords were inserted velamentously into the single placenta 5 cm. apart, and were tied together in a figure 8 double knot sufficiently tight to flatten their substance. In Newman's case the two cords sprang from the centre of the single placenta about one inch apart. Each cord was about 24 inches long, and "about midway between the umbilicus and the placental attachment of the funis the cord of the first child was tied in a single knot, and passing through the noose so formed was the cord of the second child, which, on account of the tightening of the knot, was completely strangulated."

The first child was born alive and well, but the second dead and livid (not macerated), death having apparently occurred during labour. In Weston's case the cord of one twin had passed through a knot on the cord of the other; the latter was then tied so tightly that the circulation in both cords was interrupted and both children killed three weeks before birth.

The cases, 26 in number, of foetal death due to true knots on the cord which I have been able to collect from the literature are given in the following table:—

Observer.	Source.	Age.	Parity.	Alleged cause.	Symptoms.	Length of cord.	No. of knots.	Situation of knot.	Variety of knot.	Presentation.	Remarks.
Frank.	<i>Amer. Journ. Obst.</i> 1907, 55, 790.	31	1	None. Some excess of liquor amnii.	Cessation of fetal movements only.	90 cm.	1	30 cm. from placenta.	Simple.	—	—
Wallinger.	<i>Brit. Med. Journ.</i> , 1908, ii, 147.	49	13	None.	Child seemed to turn over, then movements ceased.	—	1	9 ins. from umbilicus.	—	Breech.	Knot tied so tight as to stop circulation.
Sankey.	<i>Lond. Obst. Trans.</i> , iii, 413.	43	6	None.	Movements grew daily fainter from 6th month.	—	1	Middle.	Simple and single.	—	Knot not very tight—possibly not cause of death.
Passot.	<i>Rev. Med. et Chir. de Paris</i> , 1869, T v, 370.	—	—	—	Movements gradually lessened.	110 cm.	2	1 at inferior 1 at the superior third.	Simple	Vertex.	Both knots very tight; umbilical vein could not be injected past the knot.
Woets.	<i>Ann. de la Soc. Med. Chir. de Bruges</i> , T iii, 1842.	—	5	—	—	14 ins.	—	Middle	—	—	Tight.
Grieve.	<i>London and Edin. Monthly Jl.</i> , 1842, p. 23.	—	—	3 wks. before term seized with labour pains and slight haemorrhage. Passed off with opium.	—	—	—	Middle.	—	Vertex.	Tight enough to interrupt the circulation.



Observer.	Source.	Age.	Parity.	Alleged cause.	Symptoms.	Length of cord.	No. of knots.	Situation of knot.	Variety of knot.	Presentation.	Remarks.
Piogety.	<i>Bull. de la Société Anat. de Paris</i> , 1852, xxvii, 176.	—	I	—	—	—	I	Centre.	—	—	On untying it two distinct depressions left.
Hannay.	<i>Lond. Med. Gazette</i> , 1841, p. 122.	28	3	Sudden movement of mother. No hydramnios.	Tumultuous motions of foetus followed by cessation.	—	I	Near centre.	Single.	—	Cord once round neck. Knot tightly drawn. Part of cord knotted only half thickness of the rest; arteries from knot to foetus injected. Part of cord beyond exsanguine, also placenta.
Smellie.	"Theory and Practice of Midwifery," vol. ii.	—	—	Colic.	None except colic.	—	I	10 hand-breaths along.	—	—	Cord "swelled and livid" and knot tight.
Géry.	<i>l'Union Méd.</i> , Series 3, 1876, xxii, 886.	32	2	—	Tumultuous movements of foetus followed by gradual cessation.	—	I	Junction of umbilical two-thirds with placental one-third.	—	—	Albuminuria; placenta showed apoplectic hæmorrhages.
Augouard.	Ditto.	—	—	—	Cessation of foetal movements only.	—	I	—	—	Breech.	Tight knot where loops of knot crossed the cord, reduced to one-fifth its normal bulk. The compressed parts appeared fibrous.

Observer.	Source.	Age.	Parity.	Alleged cause.	Symptoms.	Length of cord.	No. of knots.	Situation of knot.	Variety of knot.	Presentation.	Remarks.
Piogety.	<i>Bull. de la Soc. Anat. de Paris</i> , 1852, xxvii, 176.	—	I	—	On coming out of her bath had felt child move very actively. Since then had ceased to move.	—	1	Towards middle.	—	—	Cord exsanguine below but very swollen above. Two deep impressions present at level of knot.
Billi.	<i>Ann. Universale di Medicina</i> , 1857, clxi,	24	2	—	—	91 cm.	1	14 ins. from placenta.	—	Breech.	Cord formed two loops round trunk, the 2nd of which showed a true knot. Injections into the vein could not pass knot.
Billi.	Ditto.	38	1	None known.	Fœtal movements became very violent at 6th month, continued so two months, then ceased completely.	26 cm.	1	Middle.	—	Vertex.	Cord looped twice around neck of fœtus; the second showed a tight knot.
Belluzzi.	<i>Bulletino della Scienza medica di Bologna</i> , Serie iv, Vol. xiii, 1860, p. 288.	—	Multip.	—	Violent movements which ceased at end of 8th month.	23 cm.	1	9 ins. from navel.	Simple.	—	Cord around neck and knot tight enough to completely interrupt circulation.

Observer.	Source.	Age.	Parity.	Alleged cause.	Symptoms.	Length of cord.	No. of knots.	Situation of knot.	Variety of knot.	Presentation.	Remarks.
Canivet.	<i>Ann. de Gynécologie</i> , 1875, iv, 268.	38	5	—	—	95 cm.	1	10 cm. from navel.	—	Vertex.	First of twins; second alive and well. Cord three times round neck of foetus. Between knot and umbilicus cord congested. Permanent grooves in knot and injection of vein failed to pass it.
Weston, E. B.	<i>Amer. Journ. Obst.</i> , 1893, xxviii, 144.	—	1	—	Stooped to lift some heavy object and on rising felt unusual commotion in abdomen but no foetal movement after.	—	1	—	—	—	Single, tightly drawn knot which completely interrupted the umbilical circulation.
Bonnaire and Schwab.	<i>l'Obstetrique</i> , x, 254, 1905.	19	1	—	—	77 cm.	1	—	Old.	—	Hydrocephalic fetus.
					Between knot and foetus cord was pale red, between knot and placenta purple and thick. Knot was impossible to untie; jelly of Wharton disappeared. Vessels of cord completely impervious to injection; placenta microscopically is oedematous. No evidence of syphilis in placenta or elsewhere.						
Veit.	<i>Zeitschr. für Geb. und Gynäkologie</i> , xxv, 367, 1893.	—	—	—	Movements ceased suddenly 14 days before delivery.	—	1	—	—	—	Single coil of cord round neck plus true knot which rests against anterior surface of neck. Post-mortem examination failed to show any other cause of death.

Observer.	Source.	Age.	Parity.	Alleged. cause.	Symptoms.	Length of cord.	No. of knots.	Situation of knot.	Variety of knot.	Presentation.	Remarks.
Bartscher.	<i>Monatsschr. f. Geb.</i> 1861, p. 364.	—	5	Possibly hydramnios. Cord had very little jelly.	Fœtal movement at end of 7th month got very active, then ceased.	25 ins.	1	—	—	—	Cord always round neck in previous births. Cord twice round neck.
<p>The knot was difficult to undo and the coils around the neck were drawn so tightly that the child was almost decapitated; the soft parts of the neck were pressed tightly against the vertebral column.</p>											
Holzappel.	<i>Zeitschr. für Geb. und Gynäkol.</i> , Bd. lxxiv, Hft. I.	24	1	—	Cessation of fœtal movements 2 days before onset of labour.	118 cm.	1	Middle.	—	—	Cord had only one artery and one vein. Fœtal half of cord œdematous; part between knot and placenta thin and pale. In fœtal half of cord vessels had walls thickened partly by œdema and partly by increase of muscular and fibrous tissue.
Crawford.	<i>Surg., Gyn. and Obstet.</i> , xxxiv, 546.	44	6	Undue activity of fœtal movements.	Cessation of fœtal movements.	Normal.	4	—	—	—	Cord twice round neck. Child normally developed but macerated.

Observer.	Source.	Age.	Parity.	Alleged cause.	Symptoms.	Length of cord.	No. of knots.	Situation of knot.	Variety of knot.	Presentation.	Remarks.
Browne, F. J.	Not published.	31	4	None known.	Cessation of movements 3 weeks before delivery.	60 cm.	1	Middle.	Simple.	--	Knot tightly drawn. Foetus macerated.
Browne, F. J.	<i>Edin. Obstet. Trans.</i> , May 10th, 1923.	18	2	None.	None.	--	1	2 ins. from foetal end.	Simple.	--	Acardiac foetus. Papyracous.
Cuthbert.	<i>Obst. Journ.</i> , 1874-5, ii.	30	Several previous children.	Long cord.	Abortion.	17 ins.	1	Under coils around neck.	Simple tight.	--	Foetus 3½ mons. Cord 2½ times length of foetus.
Cleveland.	<i>Obstet. Trans.</i> , Lond. 1872, xiii.	--	3	--	None.	17 ins.	1	3 ins. from navel.	--	--	3 ins. from umbilicus cord tied in single knot round neck of foetus and afterwards twisted on itself so as to resemble a noose.

ANTENATAL DEATH DUE TO THE CORD ENCIRCLING AND  
COMPRESSING THE CHILD'S NECK.

It is very rarely indeed that this condition leads to foetal death except during delivery, but a few cases have been recorded.

In Bartscher's case the woman was pregnant for the fifth time. The previous four children were healthy, but each had been born with the cord around the neck. At the end of the seventh month a very severe pain was complained of in the right lumbar region, and at the same time the foetal movements became very active. This pain lasted but a few days, and with its cessation foetal movements also ceased. Next day the mother complained only of a heavy weight in the abdomen, then, ten or twelve days after, she complained of repeated shivering fits and sickness. Delivery occurred at the end of the ninth month and was slow and tedious. The liquor amnii was copious and foul smelling and the foetus macerated. The cord, 25 inches long, had very little Wharton's jelly and was in some parts ligamentous. It had a true knot and encircled the neck of the child twice, and *so tightly that the soft parts were compressed against the vertebral column.*

*Hillairet's case:* In this case the history was as follows :

C<sub>1</sub> miscarriage at six months.

C<sub>2</sub> full time healthy girl; cord twice round neck; born asphyxiated, but restored.

C<sub>3</sub> abortion three months.

C<sub>4</sub> female at term; cord once round neck; alive and well.

C<sub>5</sub> boy, full time; cord once round neck.

C<sub>6</sub> 4 mos. male foetus, 9 cm. long. The cord was not inserted in the middle line of the foetus but somewhat towards the right.

From this point it passed to the right, outwards and backwards, round the child's side, making a deep furrow between the lower ribs and the iliac crest. Thence it crossed the back diagonally, making there also a deep furrow until it reached the highest point of the left scapula, then across the left shoulder and over the anterior surface of the neck, over the right lateral surface, across the back of the neck, and so returned to the left shoulder after having made a complete circle. It continued to coil itself around the neck, and in this way made three complete turns, after which it had all been used up. The constriction had almost completely amputated the head, the constricted part being cone-shaped, the base of the cord being above and the apex below. At the apex the

head was only united to the trunk by a pedicle not more than  $1\frac{1}{2}$  mm. across.

*Trélat's case* : The foetus had the appearance of an abortion of 3-4 months, length 9-10 cm. The cord, very slender at its origin from the umbilicus, formed a loop which kept the right leg tight against the abdomen and lower part of the thorax. The cord passed thence around the neck two or three times, making a deep trench, and from there it wound itself around the upper part of the trunk three or four times, and fixed the right upper limb, over the wrist of which it passed, the forearm being flexed on the arm. On the left side the cord passed under the axilla. From the illustration accompanying the text the cord appeared tight enough to have arrested the circulation in the neck, for a deep groove is present in the neck and upper part of chest. The foetus was evidently macerated.

A similar condition was present in Blume's case, reported by Schroeder, the soft parts of the neck being compressed even to the vertebral column by several coils of cord encircling it.

In a case described by Cleeman the cord encircled the neck and left arm three times, the latter being perpendicularly elevated and closely bound by the cord to the side of the head. The foetus was dead, about the fourth month of development, and the author considered death to be due to the interference with the cerebral circulation caused by the constriction of the neck.

If the cord encircles a limb the circulation in the former may be sufficiently interfered with by the pressure on the limb to cause foetal death. Such cases, however, seem to end more frequently in partial or complete amputation of the limb, with continued life of the foetus.

In a case described by Sinkler the pressure of the cord had caused a deep sulcus on the limb, and the consequent compression of the cord had led to the death of the foetus. This condition would arise when the cord had become wound around the limb at a very early stage of development, and the loop failed to become correspondingly large as the limb increased in girth.

#### TORSION OF THE CORD.

Like knots on the cord, this is one of the rare causes of foetal death. According to Dohrn, the condition was first described by Ruysch in 1691. Probably the best paper on the subject is Clantreuil's monograph, and Dohrn, in 1861, collected 85 cases from the literature. The torsion may affect the entire cord and the number of twists may be very numerous, Dohrn finding 85 on a

cord nine inches long, belonging to a foetus at the end of the fourth month of pregnancy, and Meckel 95 on a cord four inches long. In a 12 inch cord in my own collection there are 49 twists. Frequently, however, the inch or two of cord close to the umbilicus is alone affected owing, it is said, to the scarcity of the jelly of Wharton at that situation; less often a similar area close to the placenta is involved, or various parts of the cord may be affected even in the one specimen. Again, the inch or so of cord close to the umbilicus may be extremely constricted. Very slight or no torsion of this part may be present, but there may be excessive twisting of the thicker part of the cord as in one of Dohrn's cases. Excessive constriction of the cord at its foetal end may be the only abnormality present, and twisting be entirely absent.

*The Normal Twisting of the Cord:* A certain amount of twisting of the cord is, of course, physiological in the human subject, the arteries being twisted around the vein usually from right to left, and its function is probably protective, the firm and incompressible arteries preventing injurious pressure upon the thin walled, deeper lying vein.

Neugebauer found that out of 160 cords, 114 were twisted to the left and 39 to the right, while seven showed no twisting whatever. (By "to the left" is meant that starting from the anterior surface of the cord at the umbilicus, the cord is directed towards the left, thence it passes behind, and from there to the right, and so on until the placenta is reached.) Tarnier, out of 150 cords, found the spiral directed 105 times from right to left and 45 times from left to right. Various explanations of this physiological torsion have been given, probably the most satisfactory being that of John Simpson, who put it down to the fact that the right iliac artery is more the direct continuation of the aorta than the left iliac. The aorta lies, in the dorsal region of the foetus, parallel to the spinal column and on its left side, but as it approaches the pelvis it curves towards the right with the result that it seems to be continued into the right iliac while the left iliac appears to be a branch, is smaller, and receives a smaller supply of blood. This inequality will be carried into their respective hypogastric branches. "The foetus floating freely in a fluid readily gives way to the recoil acting on its pelvis, and the right artery, having the greater power of recoil, will determine the direction of the rotatory motion which ensues. Thus, supposing the placenta to be attached to the fundus of the uterus and the foetus floating with its face towards the placenta, then its rotatory motion will be by its cephalic and pelvic ends passing in succession with regard to the uterus from right to left anteriorly, and from left to right posteriorly. This rotation con-



tinues until the natural rigidity of the vessels offers a sufficient resistance and they cease to yield further."

Allen attributes the twisting to the growth of the arteries being more rapid than that of the veins, so that the former are obliged to take a tortuous course in order to accommodate their increased length.

Mutel, Vermelin and Dombay have recently explained torsion on mechanical principles and point out that a cylinder fixed between two plane surfaces, on or with one of which it is free to turn, can only increase in length by assuming the form of a spiral. The cord they regard as a vascular cylinder contained between two planes situated at a constant distance from each other. These planes are the placenta and the fœtus, and the constant distance is maintained by the tone of the uterine wall and suspension of the fœtus in the liquor amnii.

*Causes of Pathological Torsion.* Various causes have been invoked from time to time to explain this condition. It is most common in multiparæ which is supposed to indicate that the laxity of the abdomen and the greater size of the uterine cavity allow free foetal movements and thus predispose to excessive torsion. Boys are more commonly affected than girls, and it is supposed that the former are stronger and more active, and that the active movements are an important cause. In Spiegelberg's figures, of 99 cases reported by various authors there were 60 males and 39 females. According to Chantreuil, the chief predisposing causes are excessive foetal movements and an abnormally long cord. The last must be considered in relation to the foetal age as the normal length of the cord at different periods of development is approximately equal to that of the fœtus; in most of the recorded cases the length of the cord considerably exceeded this standard. Spiegelberg states that very active movements of the fœtus are the cause, or the exposure of the body of the mother to violent and prolonged shocks. A similar explanation has been invoked by Noegerath, who has seen three cases of excessive torsion following a violent fall. According to Breit, excessive torsion can only occur when the jelly of Wharton is scanty. Simpson, whose theory of the cause of physiological torsion was quoted above, thought that excessive torsion was due to abnormal action of the heart in inflammatory affections of the fœtus. A more likely explanation would appear to be that it is due to the causes of physiological torsion acting to excess on account of less than normal resistance by a very thin cord to the force that produces the twisting, the thinness of the cord being due to the absence, more or less complete, of the jelly of Wharton and affecting the whole or only part of the cord.

*Changes in the Cord in cases of Excessive Torsion.* Unlike physiological twists, those in the pathological variety remain permanent after separation of the foetus and the placenta. They can be forcibly untwisted, but on leaving go one of the ends they at once regain their former appearance. In a specimen of pathological torsion in my possession, obtained by Dr. William Fordyce from a macerated foetus, after forcibly undoing the twists in a short length of the cord it is seen that along one surface corresponding to the inner mutually compressed surface of the spirals the cord is flattened and there is a fibrous band 2 mm. broad which limits the stretching of the cord and causes it to be permanently convoluted, very much as the mesentery of the intestine being shorter than the intestine itself prevents it from being straightened out. On the opposite free surface the cord is rounded. It is impossible that such a condition could have arisen after death. I mention this because previous to examination of this specimen I had thought that pathological torsion might be of post-mortem origin. Spiegelberg evidently believes that some originate after death, for he says (*loc. cit.*, p. 478): "post-mortem torsions can only be due to the foetus being twisted in consequence of movements of the mother." While they may possibly sometimes be of post-mortem origin, the case that I have described proves that they are not always so.

A case described by Heaney is of interest from the same point of view. The patient was a primigravida, aged 40, whose pregnancy was normal until within two weeks of the expected date of delivery, when she felt a violent commotion of the foetus, after which all movements ceased. Six days afterwards a macerated foetus was born, which showed no evidence of syphilis. The cord was markedly twisted, the strongest twist being about the centre, and both foetal and maternal ends were œdematous. He considers this œdema to be evidence that the torsion had existed before death.

The cord is usually excessively thin. In my own case it was not more than 2-4 mm. in diameter and was of firm consistence. At intervals there were, however, three or four localized accumulations of jelly—false knots—the largest of which measured over 1 cm. in diameter. At these thickened areas the cord was not twisted. The naked eye appearances are such that it seems impossible for an effective circulation to be maintained through such a cord. Out of 85 cases collected by Dohrn from the literature, the state of the vessels was mentioned in 15. Of these the vessels were permeable in 13 to injection or a very fine probe, in one they were permeable only after untwisting the cord, and in one they were completely impermeable. Dohrn, in a case of his own, in which the foetal length was 13 inches and that of the cord 18 inches, the latter being 28 times twisted from right to left with a marked

constriction at the foetal end in which there was only one twist, gives careful measurements of the vessels. In the stenosed part the vein had a diameter of half a line, a little above this part a diameter of  $4\frac{1}{2}$  lines, and in the remaining parts of the cord, 4 lines. The lumen of the left artery was 2 lines, and in the stenosed part, half a line. The right artery had everywhere, including the stenosed portion, a lumen measuring 2 lines.

In my own case microscopic examination showed that at one end the vein was patent, but the two arteries closed. In the other end one artery was quite closed and the other almost so. There seemed to be no thickening in the walls of the vessels. The normal walls seemed to have adhered from pressure.

Occasionally the torsion may be so extreme that the cord is twisted off close to the navel, as in the case described by Hirsch occurring in a twin pregnancy. The first foetus was a dead born male at about the beginning of the sixth month of development the second entirely healthy and at term. The cause of death of the first twin was a complete twisting off of the cord so that the foetus lay free in the amniotic cavity.

*Time at which Torsion occurs.* Neugebauer is of opinion that pathological torsion usually develops during the fourth month. In 64 cases Dohrn found that in 13 the foetus at the time of death had reached the end of the third month; in 15, four months; in five, five months; in eight, six months; in 22, seven months; and in one, eight months. It therefore most frequently occurs at a time when the foetus is small, and is able to move freely in the liquor amnii.

#### LOCALIZED CONSTRICTION OF THE CORD.

This in itself may be a cause of foetal death, as in one of my cases, but it is frequently associated with excessive torsion. Not infrequently, however, localized constriction with associated vascular stenosis or obliteration is the only change present. In this condition certain areas of the cord are extremely slender, and of a firm and fibrous consistence. The change is most frequently found at the foetal end close to the umbilicus, where it involves the first inch or so of the cord. This was its situation in seven cases described by Landsberger. In a case described by Froedrich there were numerous circumscribed areas of constriction throughout the cord. Again the constriction may be found at the placental end alone. Sometimes the thin part of the cord may be excessively twisted, as in the case of Andérodias and Brandeis. The patient was a primigravida aged 28, whose pregnancy was normal till just before the seventh month when she noticed that foetal movements

ceased. Six days afterwards a macerated child was born. There were no signs of syphilis in foetus or placenta, nor could any cause of death be found, until on examining the cord, which was 40 cm. long, it was seen to be divided into two distinct portions. The one towards the placenta was the longer and was bulky in its entire length. The other or foetal portion 5-6 cm. long, was thin and became more so as it neared the umbilicus. The thick part of the cord was scarcely twisted at all, while the constricted portion was markedly twisted, especially near the umbilicus. Microscopic examination of the twisted thin part showed narrowing of the umbilical arteries and thrombus formation within them as though they had been ligatured. The umbilical vein was normal. According to Dohrn, Braun, Chiari and Spaeth observed 19 cases of this kind which is probably, therefore, the most common variety. In Dohrn's case there was but one twist in the constricted portion, which was close to the navel and about 1 cm. long. The rest of the cord was of medium thickness and was 28 times twisted from right to left. The vessels of the cord were shown by injection to be completely permeable though their lumen was much narrowed. In my own series there is one case in which death was apparently due to a localized constriction of the cord with arterial obliteration. The history was as follows:—

Three para, aet. 27. First child still-born, easy labour, at term. Second full time, alive and well, aged two years. Mother seemed healthy; no evidence of syphilis. Wassermann reaction negative. L.M.P. January 28th. No foetal movements felt since July 31st, previous to which time pregnancy appeared normal, no movements being felt until August 25th. She was sent by her doctor to hospital, where foetal death was diagnosed and labour induced on August 29th, a dead foetus being born next day. The foetus, a much macerated female, weighed 750 grms., length 34.5 cm. Placenta 250 grms.; decidual surface somewhat fibrous in appearance, and at some parts from this surface areas of gelatinous looking tissue penetrated into the placental substance and sometimes almost reached to the foetal surface. Here and there was a little sub-amniotic blood clot. On section the placenta looked spongy, but the vessels seemed abnormally thickened and stood out prominently, while microscopically the placenta was very non-vascular but the villi were not enlarged. Here and there were one or two still patent vessels, but the walls of these were very thick so that the lumina were almost obliterated. The appearance was *not* that of a syphilitic placenta. Cord 18 inches long, brown and macerated, but otherwise seemed normal except for a small part at its root (the foetal end) about  $\frac{3}{4}$ -inch in length, in which the cord was extremely firm and slender, being only 2-3 mm. in diameter. There

was one twist in the cord at this point. It looked as if the jelly were absent. The hypogastric arteries inside the abdomen appeared to naked eye examination to be normal, and the same applied to sections of the cord taken elsewhere. Microscopically, the arteries in the constricted area were completely obliterated. The vein was still patent but the lumen small. The jelly of Wharton was very fibrous and had not the normal myxomatous appearance. The lumina of the arteries seemed to be occupied by fibrous tissue, which was intimately blended with the vessel walls so that but little trace of the latter remained.

It is difficult in this case to say what was the primary condition. There are two possibilities: (1) that there was a localized fibrosis of the Whartonian jelly which caused pressure obliteration of the arterial lumina. There is, however, no evidence in the microscopic sections that there is a mere *adhesion* of the arterial walls to each other. There is rather a new formation of fibrous tissue inside the arteries, and this makes more likely the second explanation, viz. (2) that the primary condition is an arteritis obliterans with thickening of the tunica intima and tunica adventitia, the latter secondarily involving and leading to fibrosis of the Whartonian jelly surrounding it. In this connexion a case described by Cavasse is of interest. The mother was healthy and in her second pregnancy; the pregnancy was normal until the eighth month when movements ceased to be felt. The foetal heart was no longer heard and the foetus was born by the breech 20 days later. The placenta was normal and the cord showed the usual appearances to about a distance of 2 cm. from the umbilicus, at which point it became narrowed to the thickness of a small penholder, and was hard and fibrous and not twisted. On section of the cord, a centimetre from the point where narrowing began, a clot was found in the vein, at first red and soft, then becoming firm, hard and white, and adherent to the wall at the narrowed part but still easily separated. The lumen of the vein at the narrowed part was not more than one-third of that at the normal part. The walls were more thickened and the jelly of Wharton completely absent. The vein, emptied of its clot, was permeable though of small volume. The liver was small, but the other organs were not examined. Cavasse thought the condition a phlebitis and that it had existed for some time before death. There was no specific history nor other circumstance to explain the occurrence. The cord was not twisted nor subjected to pressure, neither had there been any fall or blow on the abdomen. The phlebitis had evidently lasted for some time; the foetus was of small size, considering its age, so its nutrition was probably interfered with; the foetal movements were very pronounced during the two or three days preceding their entire cessation.

In my own case it is difficult to dissociate the cord lesion from the obliteration of the vessels in the placenta. The condition is probably an arteritis obliterans of obscure origin affecting the intima and adventitia of the cord vessels as well as those of the placenta. In the case of the former the fibrosis had in all probability spread to and involved the Whartonian jelly and thus caused the area of localized constriction. A similar explanation is probably correct in the case of Cavasse, although here thrombosis set in before the venous lumen was obliterated.

#### SYPHILIS OF THE CORD.

The most frequent histological finding in cord syphilis is round cell infiltration of the walls of the vessels. It affects the wall of the vein more frequently and more intensely than that of the artery. The entire circumference of the wall of the vein may be infiltrated and the jelly of Wharton immediately surrounding, or it may affect chiefly or entirely the outer third. In one of my specimens only one side of the vessel was affected and the other had entirely escaped. The artery may show a similar change, but it is less frequently found than in the vein and is rarely so intense as in the latter. The nuclei of the round cells are usually undergoing karyorrhexis. This inflammatory reaction is sometimes the only change evident, and the vessel wall, whether artery or vein, may show no increase in thickness. Sometimes, however, there is found a marked proliferation of the tunica media which may almost or entirely obliterate the lumen. This, in my experience, is most frequently found in the more virulent cases of syphilis, especially in the cords of fresh infants born prematurely and whose organs contain spirochaetes and show well marked syphilitic changes. In all my cases this thickening is entirely of the tunica media, the inner zone of muscle being œdematous and vacuolated, and the nuclei of the muscle fibres and of the connective tissue cells undergoing karyorrhexis. It is unusual, in my experience, to find intimal thickening, although the latter is the principal change described by some observers.

It is doubtful whether the hypertrophy of the media is due to syphilis or is merely a work hypertrophy consequent upon the endarteritis obliterans in the placental vessels. Probably the latter is the correct explanation. The phlebitis may lead to thrombosis with complete closure of the lumen and consequent death of the fœtus.

*Spirochaetes in the cord.* Grafenberg, in 1909, reported that in 39 spirochæte positive fœtuses he had found the spirochæte in the umbilical cord in every case. Bab found then in only 9.4 per cent., and Mohn in 78 per cent. of spirochæte positive fœtuses. Emmons

found them in one of three spirochæte containing fœtuses, but in none of 27 other cases suggestive of syphilis. He concludes that they are only rarely found in the cords of syphilitic infants, that a large proportion of infants shown to be syphilitic by examination of the placenta, as well as by characteristic post-mortem findings, with spirochætes demonstrable in the liver, failed to reveal spirochætes in the cord after extensive search, and that a negative diagnosis cannot be made by examination of the cord alone. According to Grafenberg, they are much more likely to be found close to the fœtal end, rarely towards the placental end. They are found most often in the walls of the vessels, and especially in that of the vein, chiefly in the media and diminishing in numbers towards the adventitia and the intima. Seldom does one find an isolated spirochæte in the jelly of Wharton. Examination of the fœtal end of the cord may therefore yield valuable confirmatory evidence of the presence of syphilis in the fœtus; indeed, Grafenberg goes so far as to say that spirochætes are always present in the cords of congenital syphilitics, whether fresh or macerated, and that if spirochætes are demonstrable in the cord there are almost always other signs of syphilis in the child, such as pemphigus, hæmorrhagic diathesis, etc. It is noteworthy, however, that he failed to demonstrate spirochætes in the cords of eight apparently healthy fœtuses born of syphilitic mothers, three of whom suffered at birth from secondary syphilis. This would seem to be conclusive evidence of the invalidity of his statement that spirochætes are always present in the cords of congenital syphilitics. We know that spirochætes are not always demonstrable in the organs of syphilitic infants, and it therefore seems unreasonable to exclude syphilis because spirochætes are not found in the cord.

I have found spirochætes in the umbilical cord of only one macerated fœtus. The organs were spirochæte positive, but a very careful examination of the placenta proved negative. The organisms were present in fairly large numbers in the tunica intima of the vein but not in the media or adventitia, and so close were they to the lumen that in several instances one end of the organism projected into it. In several cases, examination of the cord of spirochæte containing fœtuses proved negative. I must confess, however, that pieces for examination were taken at random from any part of the cord and not necessarily from the fœtal end, and to this probably can be attributed my frequent failure.

#### OTHER RARE LESIONS OF THE CORD.

##### ABSENCE OF THE CORD.

Complete absence of the cord is not necessarily incompatible with development of the fœtus to term. An instance of this



interesting condition is reported by Stute. The mother was at her fifth confinement, all the other children being normal. The condition was felt on examination during labour and the fœtus was extracted, without the occurrence of hæmorrhage, by traction on the knee. The child was very small, but at full time and alive. On the back there was a cystic swelling, and to the abdomen, the placenta, normal in size, was attached over an area of 4 cm., the centre of attachment being at the umbilicus. There was no vestige of a cord. Another case was recorded by Madame Danthez. The child was born dead and macerated at the eighth month. There were hydrocephalus and exomphalos present, and the vessels of the cord were probably really present and spread out on the surface of the sac.

#### LOCALIZED VARICOSITIES ON THE CORD.

A varicosity of the umbilical vein with rupture six inches from the placental insertion and consequent death of the fœtus has been described by Pluskal. In de Zomnitz's case the cord was bent into an acute angle at a distance of 15 cm. from its placental insertion. At the extremity of this angle there was a varicosity as large as a hen's egg with a thin and ruptured wall. Dougall (quoted by Chantreuil) has recorded a case of an arterio-venous aneurism the size of a hen's egg, at about two inches from the placental insertion. Its walls were formed by the tunic of the cord, and the pouch contained a dark coloured clot surrounded by layers of fibrin. The fœtus had been dead for a long time, judging from the advanced stage of maceration.

#### ULCERATION OF THE CORD.

A specimen that was probably unique was that recorded by Jenkins, of hæmorrhage into the amniotic cavity resulting from ulceration of the umbilical vein. He attended the patient in premature labour from albuminuria at the end of the eighth month. On examination, he found the membranes intact, and when they ruptured the liquor discharged was seen to be almost pure blood. The child was dead and very pallid—apparently exsanguinated. He estimated that there was at least a quart of blood in the amniotic cavity. A small perforation was found in the umbilical cord about half an inch from its abdominal insertion. The cord was much narrowed at this point but not twisted. An examination of the affected portion revealed the fact that the jelly of Wharton was absent in one spot of a diameter of one-sixth inch and in the depth of the defective mass there was an opening into the umbilical vein. In the part of the vein surrounding the opening the unstriped muscle of its wall had undergone fatty degeneration, which was the cause of rupture.



## HÆMATOMA OF THE CORD.

Several cases of this condition have been reported. In some of the cases, but by no means always, it has led to foetal death. The hæmatoma arises from rupture of the umbilical vein by trauma (as in Couvelaire's case), torsion, varicosity, or on account of velamentous insertion. The blood contained within the amniotic sheath infiltrates the jelly of Wharton over an area of variable extent, compressing the vein and possibly also the arteries of the cord. The size of the hæmatoma varies. In Stocker's case (*vide infra*) it was the size of a pigeon's egg, in Pluskal's case the size of a hen's egg, in Wolsterdorff's case the cord was as thick as the thigh of the foetus, and in Ritter's case the swelling was 17 cm. long and measured 64 mm. in its greatest girth. Foetal death is as a rule not due to the amount of hæmorrhage but to pressure by the clot upon the umbilical vessels, especially the umbilical vein, or to the formation of a coagulum in the lumen of the latter as in Stocker's case, of which the details are as follows:—

Frau F., æt. 22. Married in spring, 1879, and soon thereafter became pregnant. Last menstrual period end of May. The pregnancy was in no way abnormal and morning sickness, at first somewhat severe, was gradually controlled. Towards the 20th week foetal movements were first observed and continued normal until three days before delivery when they became extremely vigorous and then ceased altogether. On 29th February labour pains started, delivery being accomplished by easy forceps early next morning. The foetus, a male, was premature, well developed, but dead and slightly macerated, the skull bones being movable, the sutures wide and loose and the epidermis on the scrotum detached in shreds.

On the umbilical cord an interesting condition was found. Near the middle of the otherwise normal cord there was a bluish swelling the size of a pigeon's egg. It lay on the side of the cord and occupied about half its circumference. Examination revealed the following facts:—

- (a) The umbilical vein was considerably dilated at the site of the swelling so that its lumen could hold a hazel nut.
- (b) This widened part was filled with a solid but unorganized clot.
- (c) After removal of this coagulum a lacerated opening was visible in the wall of the vein, large enough to admit the head of a pin. The clot in the dilated vein protruded through this opening and was continuous with a firm coagulum situated under the amniotic sheath of the cord.
- (d) The cord arteries were permeable but somewhat displaced.

- (e) The swelling of the cord was due partly to the dilated and obstructed vein and partly to the clot under the amniotic sheath.

In this case the foetal death was evidently due to obstruction of the vein by the clot, but this is not always fatal, for the obstruction may be incomplete as in Kromer's case in which the circulation was maintained through a chink between the thrombus and the vein wall, or in Wolsterdorff's case in which a smooth circular tunnel allowed the blood to pass through the centre of the clot. In Couvelaire's case the child was born alive and well but the hæmatoma was only formed during labour and after birth of the head. The cord was wound around the child's neck and in slipping it over the head the vein must have been injured. The hæmatoma was a very large one, occupying an extent of 10 cm. and stopping 1 cm. from the umbilicus. The wound in the vein was only 1.5 mm. in diameter and part of the clot infiltrated the wall of the vein, separating the outer from the middle coat. If the foetus in these cases dies only during labour and is therefore expelled in a fresh condition it may show all the appearances usually associated with asphyxia, such as lividity of the mucous membranes, injection of the conjunctivæ and congestion of the internal organs. This is explained by the back pressure of the blood from the obstruction in the umbilical vein through the placental capillaries and the umbilical arteries, this being no doubt facilitated by the comparatively slight difference between the blood pressure in the umbilical arteries and that in the umbilical vein. A similar condition in the body of the foetus would arise if the extravasation of blood in the cord obstructed the circulation through all three vessels. The following case recorded by Ritter is of interest from this point of view.

The child was premature, dead not more than an hour before birth, and was the first of healthy parents. The birth had been normal, the cord not being around the neck. The heart sounds had been heard by the medical attendant till within an hour of birth when they were strong and regular. After that they were not sought for and so the exact time at which foetal death occurred was unknown. On birth of the head the blue discolouration of the lips was evident as well as the swollen and injected conjunctivæ. The cord was 69 cm. long, and in the placental portion there was no pathological change. Beginning 1 cm. from the abdominal wall and extending along the cord for 17 cm. was a large hæmatoma, dark blue in colour, of which the greatest diameter was 38 mm. and the greatest girth 64 mm. The portion of the cord next the placenta showed no pathological change to the naked eye, and microscopically

the umbilical vessels appeared quite normal. On examination of the cord at the site of the hæmatoma the following appearances were observed. There was an extensive hæmorrhage underneath the amniotic sheath distending it and infiltrating the jelly of Wharton. The arteries were contracted and the vein collapsed, but its lumen increased. At the point of greatest widening of the lumen the wall of the vessel was torn through. Microscopically the wall of the vein was infiltrated with blood and the intima absent. There was no deficiency in the elastic tissue nor any evidence of inflammation.

Post-mortem examination of the foetus showed that the vessels of the cord inside the abdomen were normal, the foramen ovale and ductus Botalli patent, and that the cause of death was asphyxia. Ritter attributes the rupture to a pre-existing varix, and adopts the view of Dohrn that such varices may arise from physiological torsion of the cord which kinks the thin-walled vein and thus leads to dilatation behind the kink.

#### A RARE ABNORMALITY OF THE VESSELS OF THE CORD.

Microscopic examination of the cord of a premature infant which came under my observation revealed the following probably unique condition of matters. There was but one artery, and instead of a vein, there were numerous capillaries and a few vessels with a little fibrous stroma in their walls scattered throughout the jelly. The jelly of Wharton was much denser than usual and, indeed, was a fairly dense stroma in which the vessels lay embedded. Here and there the capillaries had ruptured and blood in small quantities was effused into the stroma. The infant was born prematurely at the sixth month alive and well formed, but died in a few hours. There was nothing in the history or post-mortem findings suggestive of syphilis.

#### CYSTS OF THE UMBILICAL CORD.

According to Haas cysts of the cord may arise from:—

(1) The allantois. Haas, writing in 1906, could find only two cases recorded in the literature, *viz.*, those of Ahlfeld (*Arch. f. Gyn.*, Bd. 10) and Ruge (*Zeitschrift. f. Geb. u. Gyn.*, Bd. 1).

(2) The umbilical vesicle.

(3) The jelly of Wharton, either (a) from liquefaction of a hæmatoma, but no case of cyst formation from this cause has yet been demonstrated; (b) from liquefaction of the jelly of Wharton itself. Of this many cases have been described (Scanzoni, Hass, Ruysch and Heyfelder). Those arising from the allantois and from the umbilical vesicle have an epithelial lining and are therefore true cysts, but those arising from the jelly of Wharton cannot be so described.

(4) Inclusions of amniotic epithelium.

Cysts of the cord are usually very small, the largest described being about the size of a hen's egg. The smaller ones are of no clinical importance, but it is possible that a large cyst might cause death of the foetus through compression of the umbilical vein. The only recorded case of foetal death was that recorded by Scanzoni (quoted by Hass). The cyst was the size of a hen's egg and apparently arose from liquefaction of the jelly of Wharton.

#### SOLID TUMOURS OF THE CORD.

Only eight cases of this rare condition appear to have been so far recorded in the literature.

(1) The first case was described by Maunoir in 1820. The child had a hernia into the umbilical cord which was crowned by a strawberry-sized fungating tumour. He removed it with complete success at the age of seven months.

(2) In Lawton's case, a tumour the size of a pear, was situated in the base of a hernia of the umbilical cord and had a telangiectatic structure, but neither this nor Maunoir's case appears to have been histologically investigated.

(3) Gerdes' case, in a child a few hours old. It was four inches long, as thick as a forefinger and shaped like a cow's horn. It entered the navel with the cord and on its base were several smaller protuberances. At birth it was bright red, fairly firm, without pulsation, not diminishable in size by compression, was very smooth and vascular and had a covering of pavement epithelium. It was removed successfully at the eighth day of the child's life. Virchow described it as a telangiectatic myxosarcoma.

(4) The fourth case was examined by Kaufman and reported by him in Virchow's *Archiv. Bd. 121. S. 513.*

It was removed by Lissner in Posen in 1890. The tumour measured 16 × 6 cm. Underneath it was covered by the outer sheath of the cord, above a mantle-like membrane, obviously the amnion, which passed over the cord, while the cord ran alongside of and was incorporated in the tumour. Removal was successful. This tumour also was a telangiectatic myxosarcoma.

(5) v. Winckel's case. The child was born alive and at term, and was fairly well nourished. At birth was noticed an irregular bright red tumour of moderately firm consistence growing from the side of the cord close to its root. The tumour was 4 cm. long, 2.8 cm. thick at its base, and near its apex 1.6 cm. It was removed by the cautery on the day after birth and the infant did well at the time but died of catarrhal pneumonia 20 days later, the latter being quite unconnected with the tumour or the operation. The tumour was a telangiectatic myxosarcoma with large numbers of new

vessels and also of lymphatics—very dilated and lined by a rapidly proliferating epithelium.

(6) *Herweg's case.* This differs from all the others in that it was situated close to the placenta. It was a solid tumour with four smaller projections from the main mass. One of these was large and broad based, while three were globular and bladder like. The largest bladder was the size of a cherry, the second of a cherry stone, the third of a hemp seed. The main tumour was kidney shaped and on section its consistence and appearance resembled a fibromyoma. Length 5 cm., height 3.3 cm., breadth 3.2 cm. Section of the tumour showed calcified areas and obliquely cut vessels. Microscopically, the outer part of the tumour was formed of a non-vascular jelly-like ground substance pervaded by numerous firm wavy bundles of connective tissue fibrils and here and there spindle, rod and star shaped cells with oval nuclei. This was probably the normal jelly of Wharton stretched over the surface of the tumour. The true tumour mass lay inside this covering, and was formed of ground substance like that of the latter, but was pervaded by very numerous vessels, all of which were lined by endothelium. The vessels anastomosed freely with one another and had narrow lumina. Surrounding the endothelium and forming the vessel walls were muscle cells arranged in one, two, three or more layers. Some of the vessels, however, had only an endothelial wall. The tumour was described by Herweg as a myxangioma. The origin of the vessels contained in the tumour was, according to Herweg, as follows: A short distance on the foetal side of the tumour one of the cord arteries gave off a small branch which ran separately to the placenta; this in turn gave off a small branch which divided and re-divided in the tumour. The child was born alive and well at full time.

(7) *Case of Budin.* Fourth pregnancy. First three labours normal; present labour also normal; the child, a well nourished female, was also alive and well. The tumour, which was the size of a large adult fist (8 × 6 cm.), was situated 20 cm. from the umbilicus, surface smooth but bossed. Colour dirty greenish yellow. Its interior showed three distinct cavities, the first of which contained chocolate-like material, the second material like white of egg, and the third a creamy substance resembling vernix caseosa. The umbilical cord was incorporated in the border of the tumour and contained the usual number of vessels, none of which communicated with the cyst cavities. On the inner wall of one of the pouches there were several small projections of variable shape and size. The walls of the cavities were lined by pavement epithelium like that of the skin, and beneath this there was a connective tissue layer with numerous sebaceous and sweat glands

and hair follicles. In the second cavity, alongside of areas of dermoid type, there were other parts showing villi like those of the intestine, and covered by columnar epithelium. More deeply there were large numbers of tubular and mucous glands and smooth muscle fibres cut in various directions. The third cavity was lined by columnar ciliated epithelium. In the solid parts of the tumour, beside adipose tissue and smooth muscle fibres, there were large vessels, nerves, and nodules of cartilage and bone. The tumour was thus a teratoma.

(8) Windle (*Jl. Anat. and Physiol.*, 1891, Vol. xxv, p.441). reports a dermoid in the cord of an anencephalic foetus. The case was originally reported by Kaufmann (Virchow's Archiv Bd. cxxii, hft. 2, S. 381). The tumour was of firm consistence and almost spherical in shape, measuring 16 cm. in diameter. It was attached to the cord close to the abdomen, to which its base was connected. Microscopic examination of the tumour showed that it consisted in part of numerous branching and partially cavernous vessels, and in part of myxomatous and embryonic tissue, the author describing it as a myxosarcoma telangiectodes.

#### SUMMARY.

1. *True knots* may exist on the umbilical cord during intra-uterine life without endangering the life of the foetus. They, however, sometimes obstruct the cord circulation sufficiently to cause foetal death.

2. When knots have existed before the onset of labour they show certain anatomical peculiarities which serve to distinguish them from knots formed during labour.

3. *Encirclement of the child's neck by loops of cord* may cause antenatal death. In such cases the soft parts may be so compressed against the vertebral column that the foetal head may be almost amputated.

4. *Excessive torsion of the cord* is a rare cause of foetal death. The causes of physiological and pathological torsion are discussed, and it is concluded that an important cause predisposing to excessive torsion is insufficiency of the Whartonian jelly. The cord vessels in these cases are usually impervious.

5. *Localised constriction of the cord* is another not infrequent cause of foetal death; it is most common in the foetal end of the cord close to the navel, but may affect several portions of the cord or rarely the placental end alone. It is probable that the cause is an obliterating endarteritis, affecting the intima and adventitia of the vessels, the fibrosis spreading to the jelly of Wharton.

6. *Syphilis of the cord*: The histology of the cord in this condition is discussed; the chief change is round cell infiltration of the

wall of the vein, and proliferation, with vacuolation of the muscle cells and œdema, of the tunica media. Phlebitis with thrombosis may also occur. Spirochaetes are most frequently to be found at the foetal end, and chiefly in the vein wall.

7. Hæmatoma of the cord may sometimes lead to foetal death. The hæmatoma is due to rupture of the vein from varicosity, torsion of the cord, or injury during labour.

8. Details are given of eight cases of *solid tumour of the cord*. In three cases the structure was that of a telangiectatic myxosarcoma, in two it was a teratoma, in one a myxangioma, while in two others histological investigation was not carried out.

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