impervious between the second and the fourth days. The hypogastric arteries remain pervious at their lower portion and constitute the superior vesical arteries. A rounded cord, which is the remnant of the umbilical vein, forms the round ligament of the liver. A slender cord, the remnant of the ductus venosus, is lodged in a fissure of the liver, called the fissure of the ductus venosus.

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## CHAPTER XXVI.

### *FŒTAL LIFE—DEVELOPMENT AFTER BIRTH—DEATH.*

Enlargement of the uterus in pregnancy—Duration of pregnancy—Size, weight and position of the fœtus—The fœtus at different stages of intrauterine life—Multiple pregnancy—Cause of the first contractions of the uterus, in normal parturition—Involution of the uterus—Meconium—Dextral pre-eminence—Development after birth—Ages—Death—Cadaveric rigidity (rigor mortis).

As the development of the ovum advances, the uterus is enlarged and its walls are thickened. The form of the organ, also, gradually changes, as well as its position. Immediately after birth its weight is about a pound and a half (680 grammes) while the virgin uterus weighs less than two ounces (56·7 grammes). The neck of the uterus, while it becomes softer and more patulous during pregnancy, does not change its length, even in the very latest periods of utero-gestation (Taylor). The changes in the walls of the uterus during pregnancy are very important. The blood-vessels become much enlarged, and the muscular fibres increase immensely in size, so that their contractions are very powerful when the fœtus is expelled.

It is evident that on account of the progressive increase in the size of the uterus during pregnancy, it can not remain in the cavity of the pelvis during the later months. During the first three months, however, when it is not too large for the pelvis, it sinks back into the hollow of the sacrum, the fundus being directed somewhat backward, with the neck presenting downward, forward and a little to the left. After this time, however, the increased size of the organ causes it to extend into the abdominal cavity, so that its fundus eventually reaches the epigastric region. Its axis then has the general direction of the axis of the superior strait of the pelvis.

The enlargement of the uterus and the necessity of carrying on a greatly increased circulation in its walls during pregnancy are attended with a temporary hypertrophy of the heart. It is mainly the left ventricle which is thickened during utero-gestation, and the increase in the weight of the heart at full term amounts to more than one-fifth. After delivery the weight of the heart soon returns nearly to the normal standard.

*Duration of Pregnancy.*—The duration of pregnancy, dating from a fruitful intercourse, must be considered as variable, within certain limits. The method of calculation most in use by obstetricians is to date from the end of the last menstrual period. Taking into account, however, the various



cases which are quoted by authors, in which conception has been supposed to follow a single coitus, there appears to be a range of variation in the duration of pregnancy of not less than 40 days, the extremes being 260 and 300 days. As regards the practical applications of calculations of the probable duration of pregnancy in individual cases, the fact must be recognized that the period is variable. Dating from the end of the last menstrual flow, an average of 278 days, or a little more than nine calendar months, may be adopted.

*Size, Weight and Position of the Fœtus.*—The estimates of writers with regard to the size and weight of the embryon and fœtus at different stages of intrauterine life present very wide variations; still it is important to have an approximate idea, at least, upon these points, and the estimates by Scanzoni are given, as presenting fair averages.

At the third week the embryon is two to three lines (4·2 to 6·4 mm.) in length. This is about the earliest period at which measurements have been taken in the normal state.

At the seventh week the embryon measures about nine lines (19·1 mm.). Points of ossification have appeared in the clavicle and the lower jaw; the Wolffian bodies are large; the pedicle of the umbilical vesicle is very much reduced in size; the internal organs of generation have just appeared; the liver is of large size; the lungs present several lobules.

At the eighth week the embryon is ten to fifteen lines (21·2 to 31·8 mm.) in length. The lungs begin to receive a small quantity of blood from the pulmonary arteries; the external organs of generation have appeared, but it is difficult to determine the sex; the abdominal walls have closed over in front.

At the third month the embryon is two to two and a half inches (50·8 to 63·5 mm.) long and weighs about one ounce (28·3 grammes). The amniotic fluid is then more abundant, in proportion to the size of the embryon, than at any other period; the umbilical cord begins to be twisted; the various glandular organs of the abdomen appear; the pupillary membrane is formed; the limitation of the placenta has become distinct. At this time the upper part of the embryon is relatively much larger than the lower portion.

At the end of the fourth month the embryon becomes the fœtus. It is then four to five inches (10·1 to 12·7 centimetres) long and weighs about five ounces (141·7 grammes). The muscles begin to show contractility; the eyes, mouth and nose are closed; the gall-bladder is just developed; the fontanelles and sutures are wide.

At the fifth month the fœtus is nine to twelve inches (22·8 to 30·5 centimetres) long and weighs five to nine ounces (141·7 to 255·1 grammes). The hairs begin to appear on the head; the liver begins to secrete bile, and the meconium appears in the intestinal canal; the amnion is in contact with the chorion.

At the sixth month the fœtus is eleven to fourteen inches (27·9 to 35·5 centimetres) long and weighs one and a half to two pounds (680 to 907

grammes). If the fœtus be delivered at this time, life may continue for a few moments; the bones of the head are ossified, but the fontanelles and sutures are still wide; the prepuce has appeared; the testicles have not descended.

At the seventh month the fœtus is fourteen to fifteen inches (35·5 to 38·1 centimetres) long and weighs two to three pounds (907 to 1,361 grammes). The hairs are longer and darker; the pupillary membrane disappears, undergoing atrophy from the centre to the periphery; the relative quantity of the amniotic fluid is diminished, and the fœtus is not so free in the cavity of the uterus; the fœtus is now viable.

At the eighth month, the fœtus is fifteen to sixteen inches (38·1 to 40·9 centimetres long and weighs three to four pounds (1,361 to 1,814 grammes). The eyelids are opened and the cornea is transparent; the pupillary membrane has disappeared; the left testicle has descended; the umbilicus is at about the middle of the body, the relative size of the lower extremities having increased.

At the ninth month the fœtus is about seventeen inches (43·2 centimetres) long and weighs five to six pounds (2·27 to 2·72 kilos). Both testicles usually have descended, but the tunica vaginalis still communicates with the peritoneal cavity.

At birth the infant weighs a little more than seven pounds (3·17 kilos), the usual range being between four and ten pounds (1·81 and 4·53 kilos), although these limits are sometimes exceeded.

The position of the fœtus, in the great majority of cases, excluding abnormal presentations, is with the head downward. In the early months of pregnancy the fœtus floats quite freely in the amniotic fluid; and it is probable that the natural gravitation of the head and of the upper part of the fœtus is the determining cause of the ordinary position in utero.

The shape of the uterus at full term is ovoid, the lower portion being the narrower. The fœtus has the head slightly flexed upon the sternum, the arms flexed upon the chest and crossed, the spinal column curved forward, the thighs flexed upon the abdomen, the legs slightly flexed and usually crossed in front, and the feet flexed upon the legs, with their inner margin drawn toward the tibia. This is the position in which the fœtus is best adapted to the size of the uterine cavity, and in which the expulsive force of the uterus can be most favorably exerted, both as regards the fœtus and the generative passages of the mother.

*Multiple Pregnancy.*—It is not very rare to observe two children at a birth, and cases are on record where there have been four and even five, though in these latter instances the children generally survive but a short time, or as is more common, abortion takes place during the first months. Examples of three at a birth have been often observed.

In cases of twins it is an interesting question to determine whether the development always takes place from two ova or whether a single ovum may be developed into two beings. In the majority of cases, twins are of the same sex, though sometimes they are male and female. In some cases there are two full sets of membranes, each fœtus having its distinct decidua, placenta and chorion; in others there is a single chorion and a double amnion; but in some both fœtuses are enclosed in the same amnion. As a rule the two placentæ are distinct; but sometimes there is a vascular communication between them, or what appears to be a single placenta may give origin to two umbilical cords. If there be but a single chorion and amnion and a single placenta, it has been thought that the two beings are developed from a single ovum; otherwise it would be necessary to assume that there were originally two sets of membranes, which had become fused into one. The instances on record of twins, one white and the other black, show conclusively that two ova may be developed in the uterus at the same time. While there can be no doubt upon this point, the question of the possibility of the development of two beings from a single ovum remains unsettled.



As pathological conditions, extraüterine pregnancies occur, in which the fecundated ovum, forming its attachments in the Fallopian tube (Fallopian pregnancy) or within the abdominal cavity (abdominal pregnancy), undergoes a certain degree of development. The uterus usually enlarges in these instances and forms an imperfect decidua.

*Cause of the First Contractions of the Uterus in Normal Parturition.*—The cause of the first contraction of the uterus in normal parturition is undoubtedly referable to some change in the attachment of its contents, which causes the fœtus and its membranes to act as a foreign body. When for any reason it is advisable to cause the uterus to expel its contents before the full term of pregnancy, the most physiological method of bringing on the contractions of this organ is to cautiously separate a portion of the membranes, as is often done by introducing an elastic catheter between the ovum and the uterine wall. A certain time after this operation, the uterus contracts to expel the ovum, which then acts as a foreign body.

In the normal state, toward the end of pregnancy, the cells of the decidua vera and of that portion of the placenta which is attached to the uterus undergo fatty degeneration, and in this way there is a gradual separation of the outer membrane, so that the contents of the uterus gradually lose their anatomical connection with the mother. When this change has progressed to a certain extent, the uterus begins to contract; each contraction then separates the membranes more and more, the most dependent part pressing upon the os internum; and the subsequent contractions are due to reflex action. The first "pain" is induced by the presence of the fœtus and its membranes as a foreign body, a mechanism similar to that which obtains when premature labor has been brought on by separation of the membranes.

According to Körner, there exists in the spinal cord, at the site of the first and second lumbar vertebræ, a reflex centre for parturition. This, like other centres in the cord, is subordinate to a centre which is situated in the medulla oblongata.

The mechanism of parturition, although this is entirely a physiological process, is considered elaborately in works upon obstetrics. The first contractions of the uterus, by pressing the bag of waters against the os internum,

gradually dilate the cervix; the membranes usually rupture when the os is pretty fully dilated, and the amniotic fluid is discharged; the head then presses upon the outlet; and the uterine contractions becoming more and more vigorous and efficient, the child is brought into the world, this being followed by the expulsion of the membranes and placenta. There then follows a tonic contraction of the muscular walls of the uterus, which becomes a hard, globular mass, easily felt through the flaccid, abdominal walls. The very contractions of the muscular fibres of the uterus which expel the fœtus close the vessels ruptured by the separation of the placenta and arrest the hæmorrhage from the mother. The changes which then take place in the respiration and the circulation of the infant have been considered in connection with the development of the circulatory system.

*Involution of the Uterus.*—At four to six days, and seldom later than eight days after parturition, the uterus has sensibly advanced in the process of involution; and it is then gradually reduced to the size and structure which it presents during the non-pregnant condition, though it never becomes quite as small as in the virgin state. The new mucous membrane, which has been developing during the latest periods of pregnancy, becomes perfect at about the end of the second month after delivery. It has then united, at the os internum, with the mucous membrane of the neck, which has not participated in the formation of the decidua. The muscular fibres, after parturition, present granules and globules of fat in their substance, and are gradually reduced in size as the uterus becomes smaller. Their involution is complete at about the end of the second month. During the first month, and particularly within the first two weeks after delivery, there is a sero-sanguinolent discharge from the uterus, which is due to disintegration of the blood and of the remains of the membranes in its cavity, this *débris* being mixed with a certain quantity of sero-mucous secretion. This discharge constitutes the lochia. It is at first red but becomes paler as it is reduced in quantity and disappears.

*Meconium.*—At about the fifth month there is a certain quantity of secretion in the intestinal canal, which becomes more abundant, particularly in the large intestine, as development advances. This is rather light-colored or grayish in the upper portion of the small intestine, becoming yellowish in the lower portion, and it is of a dark-greenish color in the colon. The dark, pasty, adhesive matter, which is discharged from the rectum soon after birth, is called the meconium.

The meconium appears to consist of a thick, mucous secretion, with abundant, grayish granules, a few fatty granules, intestinal epithelium, and frequently crystals of cholesterine. The color seems to be due to granulations of the coloring matter of the bile, but the biliary salts can not be detected in the meconium, by Pettenkofer's test. The constituent of the meconium which possesses the greatest physiological importance, is cholesterine. Although but few crystals of cholesterine are found upon microscopical examination, the simplest processes for its extraction will reveal the presence of this substance in large quantity. In a specimen of meconium in which a



quantitative examination was made, the proportion of cholesterine was 6·245 parts per 1,000 (Flint). The meconium contains cholesterine and no stercorine, the stercorine, in the adult, resulting from a transformation of cholesterine, by the digestive fluids, which probably are not secreted during intraüterine life.

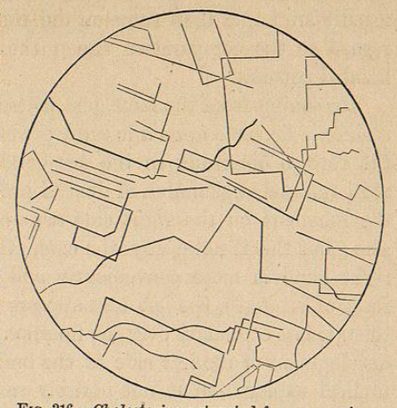

FIG. 316.—*Cholesterine extracted from meconium.*

None of the secretions concerned in digestion appear to be produced in utero, and it is also probable that the true, biliary salts are not formed at that time; but the processes of disassimilation and excretion are then active, and the cholesterine of the meconium is the product of the excretory action of the liver. The relations of cholesterine as an excrementitious product have already been very fully discussed, in connection with the bile and with excretion.

*Dextral Pre-eminence.*—Most persons by preference use the right arm, leg, eye etc., instead of the left; but exceptionally some use the left in preference to the right. There can be no doubt with regard to the fact of a natural, dextral pre-eminence; and also, that left-handedness is congenital, difficult if not impossible to correct entirely, and not due simply to habit. It would appear that there must be some condition of organization, which produces dextral pre-eminence in the great majority of persons, and left-handedness, as an exception; but what this condition is, it is very difficult to determine. An explanation which was offered by anatomists is that the right subclavian artery arises nearer the heart than the left, that the right arm is therefore better supplied with arterial blood, develops more fully, and therefore is generally used in preference to the left; but the exceptional predominance of the left hand can not be explained in this way.

The most important anatomical and pathological facts bearing upon the question under consideration are the following: Boyd has shown that the left side of the brain almost invariably exceeds the right in weight, by about one-eighth of an ounce (3·5 grammes). In aphasia the lesion is almost always on the left side of the brain. These facts point to a predominance of the left side of the brain, which presides over the movements of the right side of the body. Again, a few cases of aphasia with left hemiplegia, the lesion being on the right side of the brain, have been reported as occurring in left-handed persons. Ogle gives several such instances, in which the brain-lesion was on the right side. In two left-handed individuals, the brain was examined and compared with the brain of right-handed persons. It was found that the brain was more complex on the left side in the right-handed, and on the right side, in the left-handed. Bastian has found the gray matter

of the brain generally to be heavier on the left than on the right side. With regard to the cause of the superior development of the left side of the brain, the only explanation offered is the fact that the arteries going to the left side usually are larger than those on the right. There are no observations with regard to the comparative size of the arteries upon the two sides in left-handed persons.

Reasoning from the facts just stated, Ogle has assumed that dextral pre-eminence depends upon a natural predominance of the left side of the brain, the reverse obtaining in the left-handed. This view seems to afford the most rational explanation of dextral pre-eminence. Generally it is true that the members on the right side are stronger than the left, particularly the arm; but this is not always the case, even in the right-handed, although the right hand is more conveniently and easily used than the left. In many feats of strength, the left arm appears less powerful than the right, because there is less command over the muscles. As regards the cause of the superior development of the left side of the brain, it must be admitted that the anatomical explanation is not entirely satisfactory. It is a fact, however, that the two sides of the brain generally are not exactly equal in their development, the left side usually being superior to the right, and that the muscles of the right side of the body generally are used in preference to those of the left side.

### Development after Birth—Ages and Death.

When the child is born, the organs of special sense and the intelligence are dull; there is then very little muscular power; and the new being, for several weeks, does little more than eat and sleep. The natural food at this time is the milk of the mother, and the digestive fluids do not for some time possess the varied solvent properties that are found in the adult, though observations upon the secretions of the infant are few and rather unsatisfactory. The full activity of pulmonary respiration is gradually and slowly established. Young animals appropriate a comparatively small quantity of oxygen, and just after birth they present a much greater power of resistance to asphyxia than the adult. The power of maintaining the animal temperature is also much less in the newly-born. The processes of ossification, development of the teeth etc., have already been described. The hairs are shed and replaced by a new growth a short time after birth. The fontanelles gradually diminish in size after birth, and they are completely closed at the age of about four years.

The period of life which dates from birth to the age of two years is called infancy. At the age of two years the transition takes place from infancy to childhood. The child is then able to walk without assistance, the food is more varied and the digestive operations are more complex. The special senses and the intelligence become more acute, and the being begins to learn how to express ideas in language. The child gradually develops, and the milk-teeth are replaced by the permanent teeth. At puberty, which begins between the fourteenth and the seventeenth years—a little earlier in the



female—the development of the generative organs is attended with important physical and moral changes.

The different ages recognized by physiologists are the following: Infancy, from birth to the age of five years; adolescence, or youth, to the twenty-fifth year; adult age, to the thirty-fifth year; middle life, to the fiftieth year; old age, to the sixtieth year; and then, extreme old age. A man may be regarded at his maximum of intellectual and physical development at about the age of thirty-five, and he begins to decline after the sixtieth year, although this rule, as regards intellectual vigor, has many exceptions.

As regards nutrition, it may be stated in general terms that the appropriation of new matter is a little superior to disassimilation, to about the age of twenty-five years; between twenty-five and forty-five these two processes are nearly equal; and at a later period the nutrition does not completely supply the physiological waste of the tissues, the proportion of organic to inorganic matter gradually diminishes, and death follows, as an inevitable consequence of life. In old age the muscular movements gradually become feeble; the bones contain an excess of inorganic matter; the ligaments become stiff; the special senses generally are somewhat obtuse; and there is a diminished capacity for mental labor, with more or less loss of memory and of intellectual vigor. It is a curious fact that remote events are more clearly and easily recalled to the mind in old age than those of recent occurrence; and, indeed, early impressions and prejudices then appear to be unusually strong.

It frequently happens in old age that some organ essential to life gives way, and that this is the immediate cause of death, or that an old person is stricken down by some disease to which his age renders him peculiarly liable. It is so infrequent to observe a perfectly physiological life, continuing throughout the successive ages of man, that it is almost impossible to present a picture of physiological death; but it sometimes occurs that there is a gradual fading away of vitality in old persons, who die without being affected with any special disease. It is also difficult to fix the natural period of human life. Some persons die, apparently of old age, at seventy, and it is rare that life is preserved beyond one hundred years. The tissues usually die successively and not simultaneously, nearly all of them being dependent upon the circulating, oxygen-carrying blood, for the maintenance of their physiological properties. It has been demonstrated, indeed, that the properties of tissues may be restored for a time, after apparent death, by the injection of blood into their vessels.

After death there often is a discharge of the contents of the rectum and bladder, and parturition, even, has been known to take place. The appearance which indicates growth of the beard after death is probably due to shrinking of the skin and, perhaps, contraction of the smooth muscular fibres attached to the hair-follicles. The most important phenomenon, however, which is observed before putrefaction begins, is a general rigidity of the muscular system.

*Cadaveric Rigidity* (*Rigor Mortis*).—At a variable time after death, usu-

ally five to seven hours, all of the muscles of the body, involuntary as well as voluntary, become rigid, and can be stretched only by the application of considerable force. Sometimes, especially after long-continued and exhausting diseases, this rigidity appears as soon as a quarter of an hour after death. In the case of persons killed suddenly while in full health, it may not be developed until twenty or thirty hours after death, and it then continues for six or seven days. Its average duration is twenty-four to thirty-six hours; and as a rule it is more marked and lasts longer the later it appears. In warm weather cadaveric rigidity appears early and continues for a short time. When the contraction is overcome by force, after the rigidity has been completely established and has continued for some time, it does not reappear. The rigidity of the muscular system extends to the muscular coats of the arteries and lymphatics. During what may be called the first stage the muscles are still excitable; but when the rigidity is complete their excitability is lost and can not be restored. Cadaveric rigidity is always preceded by loss of excitability of the motor nerves.

The rigidity first appears in the muscles which move the lower jaw. Then it is noted in the muscles of the trunk and neck, extends to the arms, and finally to the legs, disappearing in the same order of succession. The stiffening of the muscles is due to a coagulation of their substance, analogous to the coagulation of the blood, and probably is attended with some shortening of the fibres; at all events, the fingers and thumbs generally are flexed. That the rigidity is not due to coagulation of the blood, is shown by the fact that it occurs in animals dead from hæmorrhage.

According to John Hunter the blood does not coagulate nor do the muscles become rigid in animals killed by lightning or hunted to death; but it is a question in these instances whether the rigidity does not begin very soon after death and continue for a brief period, so that it may escape observation. As a rule rigidity is less marked in very old and in very young persons than in the adult. It occurs in paralyzed muscles, provided they have not undergone extensive fatty degeneration.

Under ordinary conditions of heat and moisture, as the rigidity of the muscular system disappears the processes of putrefaction begin. The various tissues—with the exception of certain parts, such as the bones and teeth, which contain a large proportion of inorganic matter—gradually decompose, forming water, carbon dioxide, ammonia etc., which pass into the earth and the atmosphere. The products of decomposition of the organism are then in a condition in which they may be appropriated by the vegetable kingdom.

# INDEX.