

anastomosing branch from the umbilical vein, before it penetrates the liver, and this branch is the ductus venosus. As the inferior vena cava increases in size, it communicates below with the two inferior cardinal veins; and that portion of the two inferior cardinal veins which remains constitutes the two iliac veins. The inferior cardinal veins, between that portion which forms the iliac veins and the heart, finally become the right and the left azygos veins.

The right canal of Cuvier, as the upper extremities are developed, enlarges and becomes the vena cava descendens, receiving finally all the blood from the head and the superior extremities. The left canal of Cuvier undergoes atrophy and disappears. The upper portion of the superior cardinal veins is developed into the jugulars and subclavians on the two sides. As the lower portion of the left cardinal vein and the left canal of Cuvier atrophy, a venous trunk appears, connecting the left subclavian with the right canal of Cuvier. This increases in size and becomes the left vena innominata, which connects the left subclavian and internal jugular with the vena cava descendens.

Development of the Heart.—The central enlargement of the vascular system in the first circulation, which becomes the heart, is twisted upon itself by a single turn. The portion connected with the cephalic extremity of the embryo gives origin to the arterial system, and the portion connected with the caudal extremity receives the blood from the venous system. The walls of the arterial portion of the heart soon become thickened, while the walls of the venous portion remain comparatively thin. There then appears a constriction, which partly separates the auricular from the ventricular portion. At a certain period of development the heart presents a single auricle and a single ventricle.

The division of the heart into two ventricles appears before the two auricles are separated. This is effected by a septum, which gradually extends from the apex of the heart upward toward the auricular portion. At the seventh week there is a large opening between the two ventricles. This gradually closes from below upward, the heart becomes more pointed, and the separation of the two ventricles is complete at about the end of the second month.

At about the end of the second month a septum begins to be formed between the auricles. This extends from the base of the heart, toward the ventricles, but it leaves an opening between the two sides—the foramen ovale, or the foramen of Botal—which persists during the whole of foetal life. At the anterior edge of the opening of the vena cava ascendens into the right auricle, there is a membranous fold, which projects into the auricle. This is the valve of Eustachius, and it divides the right auricle incompletely into two portions.

During the sixth week the heart is vertical and is situated in the median line, with the aorta arising from the centre of its base. At the end of the second month it is raised up by the development of the liver, and its point presents forward. During the fourth month it is twisted slightly upon its

axis, and the point presents to the left. At this time the auricular portion is larger than the ventricles; but the auricles diminish in their relative capacity during the latter half of intrauterine life. The pericardium makes its appearance during the ninth week.

Early in intrauterine life the relative size of the heart is very great. At the second month its weight, in proportion to the weight of the body, is as 1 to 50. This proportion, however, gradually diminishes, until at birth the ratio is as 1 to 120. The weight in the adult is about as 1 to 160. During about the first half of intrauterine life the thickness of the two ventricles is nearly the same; but after that time the relative thickness of the left ventricle gradually increases.

Peculiarities of the Foetal Circulation.—Beginning at the abdominal aorta, the blood passes into the two primitive iliacs, and thence into the internal iliacs. From the two internal iliacs the two hypogastric arteries arise, which ascend along the sides of the bladder, to its fundus, pass to the umbilicus and go to the placenta, forming the two umbilical arteries. In this way the blood of the foetus goes to the placenta.

The umbilical vein enters the body of the foetus at the umbilicus; it passes along the margin of the suspensory ligament, to the under surface of the liver; it gives off one branch of large size, and one or two smaller branches to the left lobe; it sends a branch each to the lobus quadratus and the lobus Spigelii; and the vessel reaches the transverse fissure. At the transverse fissure it divides into two branches, the larger of which joins the portal vein and enters the liver; and the smaller, which is the ductus venosus, passes to the vena cava ascendens, at the point where it receives the left hepatic vein. Thus the greater part of the blood returned to the foetus from the placenta passes through the liver, a relatively small quantity being emptied into the vena cava, by the ductus venosus.

The vena cava ascendens, containing the placental blood which has passed through the liver, the blood conveyed directly from the umbilical vein by the ductus venosus and the blood from the lower extremities, passes to the right auricle. As the blood enters the right auricle it is directed by the Eustachian valve, passing behind the valve, through the foramen ovale, into the left auricle. At the same time the blood from the head and the superior extremities passes down, by the vena cava descendens, in front of the Eustachian valve, through the right auricle, into the right ventricle. The arrangement of the Eustachian valve is such that the right auricle simply affords a passage for the two currents of blood; the one, from the vena cava ascendens, through the foramen ovale, passes into the left auricle and the left ventricle; and the other, from the vena cava descendens, passes through the right auriculo-ventricular opening, into the right ventricle. It is probable, indeed, that there is very little admixture of these two currents of blood in the natural course of the foetal circulation.

The blood poured into the left auricle, from the vena cava ascendens, through the foramen ovale, passes from the left auricle into the left ventricle. The left auricle and the left ventricle also receive a small quantity of blood

from the lungs, by the pulmonary veins. Thus the left ventricle is filled. At the same time the right ventricle is filled with blood which has passed

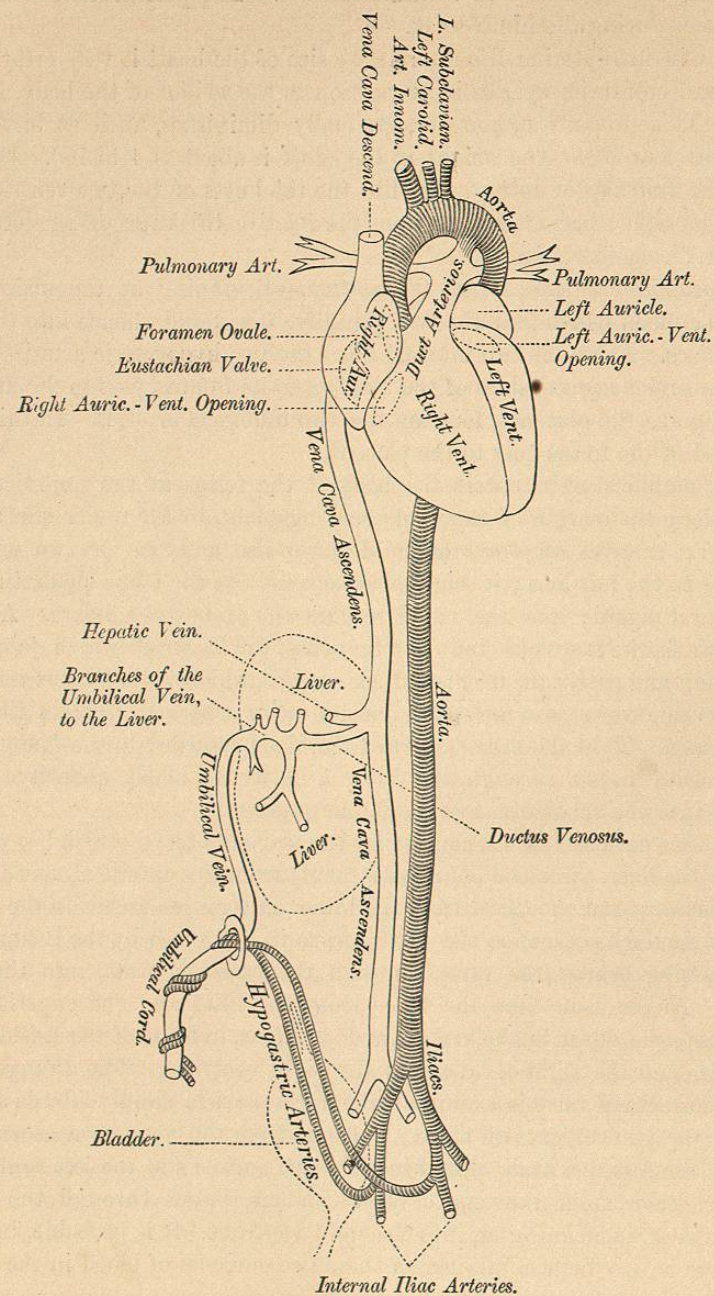


FIG. 315.—Diagram of the foetal circulation.

through the right auricle, in front of the Eustachian valve. The two ventricles, thus distended, then contract simultaneously. The blood from the

right ventricle passes in small quantity to the lungs, the greater part passing through the ductus arteriosus, into the descending portion of the arch of the aorta. This duct is half an inch (12·7 mm.) in length, and about the size of a goose-quill. The blood from the left ventricle passes into the aorta and goes to the system. The vessels of the head and superior extremities being given off from the aorta before it receives the blood from the ductus arteriosus, these parts receive almost exclusively the pure blood from the vena cava ascendens, the only mixture with the placental blood being the blood from the lower extremities, the blood from the portal system and the small quantity of blood received from the lungs. After the aorta has received the blood from the ductus arteriosus, however, it is mixed blood; and it is this which supplies the trunk and lower extremities.

In Fig. 315, which is diagrammatic, the foetal circulation is illustrated. In endeavoring, in this figure, to give a clear idea of the second circulation, no attempt has been made to preserve the exact relations or the relative size of the organs. The Eustachian valve, the foramen ovale and the two auriculo-ventricular orifices are represented by dotted lines. The liver and the bladder are also represented by dotted lines.

The Third, or Adult Circulation.—When the child is born the placental circulation is suddenly arrested. After a short time the sense of want of air becomes sufficiently intense to give rise to an inspiratory effort, and the first inspiration is made. The pulmonary organs are then for the first time distended with air, the pulmonary arteries carry the greatest part of the blood from the right ventricle to the lungs, and a new circulation is established. During the later periods of foetal life the heart is gradually prepared for the new currents of blood. The foramen ovale, which is largest at the sixth month, after that time is partly occluded by the gradual growth of a valve, which extends from below upward and from behind forward, upon the side of the left auricle. The Eustachian valve, which is also largest at the sixth month, gradually atrophies after this time, and at full term it has nearly disappeared. At birth, then, the Eustachian valve is practically absent; and after pulmonary respiration becomes established, the foramen ovale has nearly closed. The arrangement of the valve of the foramen ovale is such that at birth a small quantity of blood may pass from the right to the left auricle, but none can pass in the opposite direction. The situation of the Eustachian valve, on the right side of the interauricular septum, is marked by an oval depression, called the fossa ovalis.

As a congenital malformation, the foramen ovale may remain open, producing the condition known as cyanosis neonatorum. This may continue into adult life, and it is then attended with more or less disturbance of respiration and difficulty in maintaining the normal heat of the body. Usually the foramen ovale is completely closed at about the tenth day after birth. The ductus arteriosus begins to contract at birth, and it is occluded, being reduced to the condition of an impervious cord, between the third and the tenth days.

When the placental circulation is arrested at birth, the hypogastric arteries, the umbilical vein and the ductus venosus contract, and they become

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.

CHAPTER XXVI.

FETAL LIFE—DEVELOPMENT AFTER BIRTH—DEATH.

Enlargement of the uterus in pregnancy—Duration of pregnancy—Size, weight and position of the foetus—The foetus 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 foetus 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 embryo and foetus 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 embryo 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 embryo 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 embryo 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 embryo 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 embryo, 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 embryo is relatively much larger than the lower portion.

At the end of the fourth month the embryo becomes the foetus. 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 foetus 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 foetus is eleven to fourteen inches (27·9 to 35·5 centimetres) long and weighs one and a half to two pounds (680 to 907