COMPARATIVE IMPORTANCE OF MATERNAL BLOOD AND AMNIOTIC FLUID AS NUTRITIONAL SOURCES IN EMBRYONIC DEVELOPMENT

(UDC 612.64 : 612.39]-08)

I. A. Arshavskii

Laboratory of Physiology and Pathology of Growth, Institute of Normal
and Pathological Physiology, USSR Academy of Medical Sciences, Moscow
Presented by Academician V. V. Parin
Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 59, No. 2,
pp. 29-32, February, 1965
Original article submitted September 10, 1963

Many years of research have led us to the conclusion that the fetus receives nourishment in two ways—parenterally, with substances from the maternal blood (hemotrophic form of nutrition) and by way of the intestine with substances from the amniotic fluid (amniotrophic nutrition) [2, 4].

The idea that the fluid surrounding the fetus may serve for its nutrition is not new [15, 16, 17]. It has also been suggested that amniotic fluid is introduced into the stomach by swallowing movements performed by the fetus.

This investigation dealt with the mechanisms of nutrition from amniotic fluid and their importance in relation to normal or abnormal embryonic development.

METHOD

Dog, rabbit and cat embryos, removed from the uterus by cesarean section, were used in the experiments. The fetus remained connected to the mother, however, by the umbilical cord. The duration of normal pregnancy is known to be approximately the same in both dogs and cats (60-63 days). In the case of dog and cat fetuses, pressure was recorded in the pleural cavity and also in the esophagus from a cannula inserted into the latter. Sucking movements in the mouth cavity of the fetus were recorded by the introduction of a specially designed glass tube, connected by rigid rubber tubing to a water manometer. In other cases sucking movements were recorded from a closed teat introduced into the mouth cavity and connected through a water manometer to a Marey tambour.

RESULTS

Dog and cat fetuses were found to be incapable of swallowing movements. Small pieces of meat placed far back on the tongue of 40-55 day fetuses were not swallowed and were found in the same position.

The fetus, still connected with the mother by the umbilical cord, also failed to swallow warm saline, introduced into its mouth cavity, if it was not producing respiratory movements. It had been found earlier that saline introduced into the mouth cavity reached the stomach if the fetus was effecting respiratory movements. It had also been shown that a negative pressure of the order of 50-60 mm H_2O was created in the thoracic cavities of dog and cat fetuses in the course of each respiratory movement [1, 3, 4]. It was also established that negative pressures were created in the venae cavae, mediastinum and esophagus as well as in the pleural cavity with each respiratory movement of the fetus. The value of the negative pressure in the esophagus was 20-30 mm H_2O and occasionally, in the case of dog fetuses, 40 mm H_2O. Further investigation afforded convincing evidence that the negative pressure produced in the lumen of the esophagus was sufficient to draw saline or amniotic fluid in the mouth cavity into the fetal stomach. This negative pressure was not, however, sufficient to draw fluid from the amniotic cavity through the fetal nose and mouth, particularly as the latter is closed in the normally developing fetus.

It was found in a series of special experiments that fluid surrounding the fetus entered the mouth cavity by virtue of sucking movements. It was observed that, even in the antenatal period, sucking movements were produced in the fetus by periodic contraction of the muscles of the lower jaw and tongue and that the resultant negative pressure created in the mouth cavity led to suction of the fluid surrounding the fetus through the nares into its mouth cavity. A negative pressure of 10-20 mm H_2O is produced by each suction movement in 40-45 day fetuses. When there are several successive sucking movements values of 40-60 mm H_2O may be reached. The negative pressure developed in dog fetuses is generally 1.5 times greater than in cat fetuses. The intensity of the sucking movements and the value of the negative pressure produced was found to be dependent on the depth of anesthesia in the mother; both were reduced by fairly deep anesthesia and the sucking movements might even be arrested. In 50-55 day fetuses the negative pressure might attain values of 100-120 mm H_2O after several sucking movements. The latter were generally effected in the intervals between respiratory movements.

The ability of the human fetus to produce sucking movements has been noted on several occasions [13, 14] but this is still regarded as a manifestation of an anticipatory pattern or, as Coghill [11] put it, a "setting for the future." The results of the author's own investigations suggest that sucking movements, developing in the antenatal period, constitute a quite important adaptational function. In conjunction with the respiratory movements, they provide a means for nutrition of the fetus from the amniotic fluid. It was stated in earlier papers [1, 2, 3, 4] that respiratory movements, which have a circulatory function in the antenatal period, provide means whereby the fetus can obtain nutritive material primarily from the maternal blood and, in combination with sucking movements, they provide a mechanism for nutrition of the fetus from the amniotic fluid.

It was thought extremely important to determine whether interference with nutrition of the fetus from the amniotic fluid had any effect on fetal growth. Many different kinds of abnormality, produced experimentally by intervention in the early, embryonic period of pregnancy, were observed in the course of a large number of experiments [5, 6]. Among these abnormalities were cases of atresia of the esophagus and of the nasal and oral orifices. These deformities naturally ruled out any possibility of nutrition from the amniotic fluid. The fetuses were removed by cesarean section just before term. Some did not differ from healthy fetuses of the same litter in weight or body-length, some were larger, and some smaller. Fetuses with deformities of the types indicated did not lose the power to effect respiratory movements, and indeed, these movements appeared to be effected more intensely than in healthy fetuses. These observations suggested that, when nutrition from the amniotic fluid was impossible, there might be compensatory increase of nutrition from the maternal blood. Nutrition from the amniotic fluid was interfered with but not made impossible by deformities such as hare lip, particularly if associated with cleft palate. Although these deformities rendered sucking movements in the antenatal period impossible, the extracted fetuses did not differ in weight or size from the controls. Finally nutrition from the amniotic fluid was interfered with in physiologically immature fetuses in which sucking and respiratory functions were poorly developed; this may possibly have some connection with the development of hydramnios. In the case of dogs the quantity of fluid in the amnion was 50-80 ml between the 40th and 55th days of pregnancy. This was reduced to 30-40 ml by the end of pregnancy. The corresponding figure for cats was 30-50 ml. The quantity of amniotic fluid found in rabbits was 2.5-3 ml at the 20th day and 1-2 ml at the end of pregnancy (30th day). Hydramnios was generally observed in anencephaly, acephaly and microcephaly as well as in the presence of the deformities mentioned (atresia, hare lip and cleft palate). The quantity of amniotic fluid in dogs with these deformities might be 100-150 ml or even 180 ml. The corresponding values for rabbits are 5-8 ml or occasionally 10 ml. The author has also observed hydramnios at the end of pregnancy (5-8 ml) in rabbits when the fetuses were in a state of physiological immaturity. Hydramnios is generally considered to be due either to excessive secretion by the epithelial cells of the amnion or to retarded reabsorption [8, 10, 12, 16]. The results of these investigations suggest that this condition may also result from complete or partial interference with the use of amniotic fluid for nutrition of the fetus.

Hydramnios is generally given in textbooks of obstetrics as one of the possible causes of malformations. These investigations indicate, however, that hydramnios should be regarded as a result of the development of deformities. It is still uncertain to what extent interference with or loss of its amniotic source of nutrition affects the physiological maturity of the fetus although, as stated earlier, this development defect may have no effect on its size and weight.

LITERATURE CITED

1. I. A. Arshavskii, Fiziol. Zh. SSSR, No. 4, 32, (1946), p. 495.
2. I. A. Arshavskii, Zh. Obshch. Biol. No. 2, (1959), p. 104.
3. I. A. Arshavskii, In book: Respiratory Control in Normal and Pathological States. Moscow, (1959), p. 198.
4. I. A. Arshavskii, Physiology of the Circulation in the Intrauterine Period. Moscow, (1960).
5. I. A. Arshavskii, M. G. Nemets, and Z. F. Surovtseva, Vestn. AMN SSSR 11, (1962), p. 60.
6. I. A. Arshavskii, In book: Problems of Anthropology, Moscow, No. 15, (1963), p. 21.

7. E. L. Golubeva, In book: Analyzer Strucutre and Function in the Course of Human Ontogenesis. Moscow, (1961), p. 289.
8. V. S. Gruzdev, Obstetrics and Gynecology. Berlin, 1, (1922), p. 506.
9. V. F. Kistyakovskii, On the Origin of Amniotic Fluid and the Secretory Function of Digestive Organs in the Fetus. Moscow, (1898).
10. A. I. Petchenko, Obstetrics. Kiew, (1954).
11. G. E. Coghill, Anatomy and the Problem of Behavior. Moscow and Leningrad, (1934).
12. H. Hinselmann, Biologie und Pathologie des Weibes. Berlin, (1925).
13. D. Hooker, The Prenatal Origin of Behavior. Lawrence, (1952).
14. M. Minkowski, In book: Abderhalden. Handbuch der biologischen Arbeitsmethoden. Berlin, Sect. 5, Pt. 5B, No. 5, (1928), p. 511.
15. W. Opitz, Zbl. Gynäk. 11, 734, (1887).
16. W. T. Preyer, Specielle Physiologie des Embryo. Leipzing, (1885).
17. K. Prochownick, Arch. Gynäk. 11 , 304 (1877).
18. W. F. Windle, Physiology of the Fetus. Philadelphia, (1940).
19. E. Yordan and D. A. D'Esopo, Am. J. Obstet. Gynec. 70, (1955), p. 266.

All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.
