CHARACTERISTICS OF BLOOD GASES IN THE UMBILICAL VESSELS OF INFANTS BORN WITH ASPHYXIA

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In previous work carried out in our laboratory [1, 2, 3, 4], both in experiments on the dog fetus and during investigations on physiologically mature newborn infants, we studied the gaseous composition of the blood in the umbilical vessels with the aim of solving the two following questions: 1) what are the oxygen and carbon dioxide contents of the blood in the umbilical vein (or in the carotid artery of the dog fetus) at which the first extrauterine respiration develops?; 2) to what extent is the change in the gas content of the blood, particularly in the umbilical artery, able to serve as an index of the rate at which the lungs take over the function of respiration after birth?.

In the present work we were set the problem of finding the characteristics of the dynamic changes in the gas composition of the blood in the umbilical vessels by repeated sampling of the blood from fetuses born in a state of asphyxia. In addition, we aimed at evaluating the data obtained in order, on the one hand, to clear up several points in the mechanism of the development of primary asphyxia in infants and, on the other hand,—and this is important—to find the physiological basis of the mechanism of the efficiency of a method for the control of primary asphyxia in infants, known under the name of nonligation of the umbilical cord, or Legenchenko's method. We found no similar type of investigation in the literature.

EXPERIMENTAL METHOD

Samples of blood were examined from the umbilical artery and vein in 33 newborn infants born in a condition of asphyxia in G. L. Grauerman's maternity home No. 7. Since the method of nonligation of the umbilical cord was for resuscitation in all cases, the infants were placed in a bath of warm water (37-38°) immediately after birth in order to prevent chilling. Two to five blood samples were taken from the umbilical vessels (artery or vein) of each infant being delivered; the first was taken 20-30 seconds after birth and the remainder after every few minutes. Care was taken not to compress the umbilical vessels with the hands while taking the blood samples. A dry, sterilized syringe with a well-ground but freely movable piston was used for taking the blood samples in quantities of 2-3 ml which were sufficient for the test and for repeat (control) examinations. A Slaika manometric apparatus was used for determining the contents of gases in the blood samples which were kept in a refrigerator for 1-6 hours under oil.

EXPERIMENTAL RESULTS

A succession of blood samples was taken at specified intervals of time from the umbilical vein of 23 infants and from the umbilical artery of ten others.

For determining the physiological reasons for the effectiveness of the method of nonligation of the umbilical cord it was necessary, first of all, to establish whether the placental gas exchange through the umbilical artery is maintained between the fetus and the mother during labor. Taking into account the oxygen capacity of the blood in the human fetus towards the end of pregnancy and also that the oxygen saturation of the blood in the umbilical vein reaches 95% [5], it was natural to assume that, for maintaining the normal placental gas exchange, the oxygen content of the blood in the umbilical vein should range within the limits of 18-20%. This level is lower the higher the degree of separation of the placenta from the uterus at the time of birth.

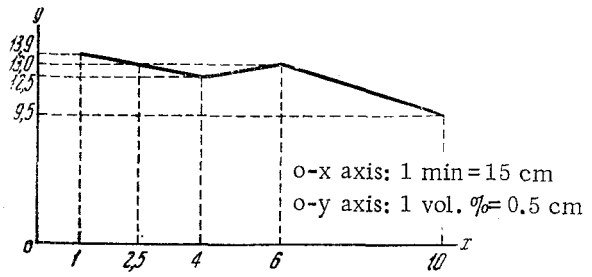


Fig. 1. Change in the oxygen content of the blood in the umbilical vein at various periods following birth (history of birth No. 981-131). Axis of ordinates – time (min), Axis of abscissae - gas content (vol. %)

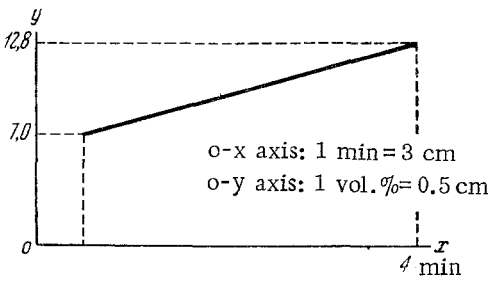
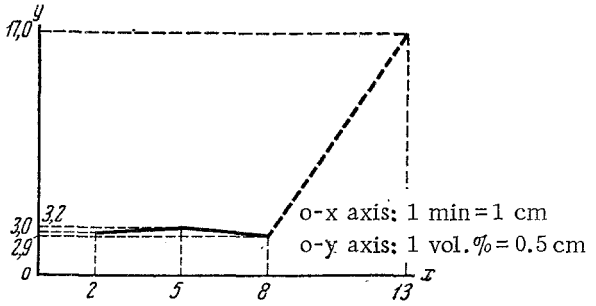


Fig. 2. Changes in the oxygen content of the blood in the umbilical vein at various periods after birth (history of birth No. 2721-239). Symbols the same as in Fig. 1.

a



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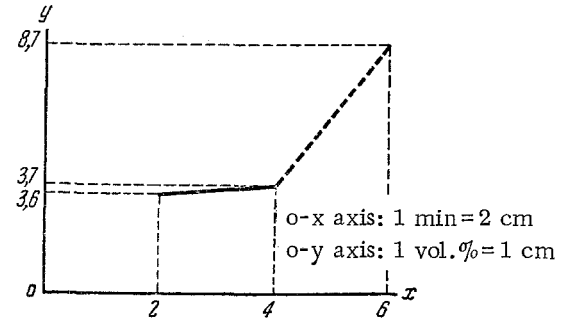

Fig. 3. Changes in the oxygen content of the blood in the umbilical artery in the newborn infant, born in a condition of asphyxia and with nonligation of the umbilical cord.
a) history of birth No. 1769-47; b) history of birth No. 2362-194.

In four infants the oxygen content of the blood in the umbilical vein after birth ranged between 15.7 and 16.9% (Fig. 1), which points to a negligible separation of the placenta and to a decidedly favorable maintenance of the placental gas exchange.

The oxygen content in the umbilical vein was between 10 and 14.6% in ten infants, from 7 to 9.6% in six infants and in three others the levels were 5%, 3.9% and 2%, respectively.

For how long is the oxygen concentration found in the first blood sample from the umbilical vein preserved?

In our observations, the first extrauterine respiration in infants, born in a condition of asphyxia and with nonligation of the umbilical cord, began 3-11 minutes after birth. The oxygen content determined within the first minute remained unchanged in the overwhelming majority of cases. In six infants we observed a pronounced increase in the oxygen content of the blood in the umbilical vein during the next few minutes (Fig. 2). These results, evidently, are due to the fact that the initial drop in the oxygen content may be dependent on, not only a partial separation of the placenta, but also on the difficulty of blood circulation in the umbilical cord produced by effects such as squeezing the cord or possibly by twisting it. After a certain period following birth, when the obstacle to free blood circulation in the umbilical vein (recovery of the umbilical cord from twisting) is removed, the oxygen content in the umbilical vein again rises.

In five infants we observed a fall in the level of oxygen in the umbilical vein and in two of them it was very marked (in one instance from 16.8% in the first two minutes to 12% in eight minutes and in the other from 13.1% in one minute to 5.2% after 4.5 minutes). These results point to a persistent, further separation of the placenta from the uterus.

From the data obtained it can be concluded that the method of nonligation of the umbilical cord may be considered to be a justified and reasonable means of controlling primary asphyxia in newborn infants only under conditions in which a continuous gas exchange is maintained with the mother's blood. An analysis which we made

furnished grounds for thinking that the efficiency of the method is based, to a considerable extent, on preventing the development of anoxia in the nerve centers and the heart, since, owing to nonligation of the umbilical cord, the infant continues to receive blood more or less saturated with oxygen.

When there has been a considerable separation of the placenta, and the oxygen content of the umbilical vein has dropped to 3-2%, or even lower in cases of complete separation, the nonligation method cannot be regarded as effective.

What other test, besides a determination of the oxygen content of the blood in the umbilical vein, can be made for ascertaining the degree to which the placental gas exchange in the asphyxiated infant is sustained? In those instances in which the oxygen content of the blood in the umbilical vein of the infant ranges from 16% to 5% over the whole period during which the umbilical cord is nonligated, the umbilical artery pulsates very distinctly. In previous work [4] it was shown that cessation of the pulsations in normal, newborn infants was due to the functional occlusion of the artery brought about by the transfer of the gas exchange from the placenta to the lungs. Since, for a short period, no extrauterine respiration occurs in infants born in a state of asphyxia there is no reason why the pulsations should cease. For many years I. A. Arshavskii has seen cases of asphyxia in newborn infants with nonligation of the umbilical cord in which extrauterine respiration had not begun within a period of 10-15 min and when the pulsations in the artery gradually diminished over a period of 2-5 minutes. At the same time, the heart did not cease work but merely weakened and this resulted in the pulsations in the umbilical artery becoming fainter or even ceasing. This result was quite plainly seen in a few instances when the oxygen content in the umbilical vein fell to 5%, and more especially when the value dropped below 5%. Hence, a more or less powerful pulsation of the umbilical artery should be considered a very essential criterion for judging the extent to which the placental gas exchange is maintained in the asphyxiated infant.

The data produced, especially those concerning cases in which the oxygen content in the blood of the umbilical vein was 14-16%, indicate that the inability of the infant to accomplish the first extrauterine respiration is dependent on the state of anoxia in the nerve centers, especially the respiratory center. As was shown in experimental work done in our laboratory [2, 3], the impossibility of making the first extrauterine respiration depends mainly on the lesion of the tissues of the respiratory center and, in this connection, on the depression of its excitability in the antenatal period. In normal newborn infants the given oxygen concentration (16-14%) appears to be an essential stimulating factor upon which the development of the first extrauterine respiration depends. In infants born with asphyxia this concentration, or an even lower one, does not appear to stimulate the respiratory center.

Our investigations showed that, during the period in which extrauterine respiration had not yet developed, the oxygen content of the blood in the umbilical artery of the asphyxiated infant was constant and ranged between the limits of 3-4.5%, depending on the oxygen level in the blood of the umbilical vein. However, as soon as the first extrauterine respiration appeared, the oxygen content in the umbilical artery more or less increased, depending on the intensity of the breathing and on the rate at which the lungs compensated (Fig. 3). As was established in previous work, it could be assumed that there was an adequate compensation by the lungs in those instances in which the oxygen content of the blood in the umbilical artery reached 18-19%. A determination of the oxygen content of the blood in the umbilical artery makes it possible to estimate the efficiency and adequacy of the first extrauterine respiration of infants born with asphyxia, the extent of compensation effected by the lungs or the degree of their partial atelectasis. As is shown in Fig. 3, this was at the time when in one infant (a) a definite approximation to an adequate compensation by the lung parenchyma was already noticed and when in another infant (b) there was still a decided partial atelectasis.

Our results established that the development of the first extrauterine respiration in the infant born with asphyxia cannot depend on the nonligation of the umbilical cord alone. Nonligation of the umbilical cord appears to be a very important factor in preventing the development of progressive anoxia in the nerve centers and their further lesions. It has been determined that for stimulating the respiratory center a reflex stimulation by the receptors in the mucous membrane of the nose or by cutaneous receptors is necessary [2]. Reflex stimulation of the respiratory center is capable not only of causing a much quicker onset of the first extrauterine respiration but of intensifying its action. Thereby, the rate of transition to a satisfactory gas exchange is increased and, at the same time, a partial atelectasis of the lungs is prevented. An estimate of the latter condition can be made, on the one hand, by determining the rate at which the oxygen level in the blood of the umbilical artery approaches the normal and, on the other hand, by observing a visual criterion such as the rate at which the pulsations of the umbilical artery disappear.

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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.