

GASEOUS CONTENT OF THE BLOOD IN THE UMBILICAL VESSELS IN INFANTS IN WHOM RESPIRATION DEVELOPS NORMALLY AT BIRTH

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The problem of the gradual change in gaseous content of the blood in the umbilical vessels which occurs at the time between normal delivery and the changeover to pulmonary respiration is important in many respects. Determination of the gaseous content of the blood, and particularly the oxygen content in the umbilical vein, gives information about the gaseous exchange occurring in the placenta before the child is delivered and while it maintains connection with the mother through the umbilicus. From the composition of the blood, and particularly from that in the umbilical vein, it is possible to determine the oxygen and carbon dioxide content at the time when pulmonary respiration starts, when it must be remembered that in normal births the umbilicus has not yet been tied off. The problem has already been solved for animals [1], but no corresponding studies in newborn infants are known to us. The results obtained by Arshavskii [1] have shown that the change in the composition of the blood gases, particularly in the umbilical arteries, reveals the rate of expansion of the pulmonary parenchyma after the first extrauterine respiratory movements. To determine the rate and the extent of the pulmonary expansion after birth, it was convenient to use the x-ray method which has been applied extensively by P. N. Serzhanin [2]. However, in addition to several practical difficulties and other undesirable complications associated with the application of this method to childbirth, as Arshavskii states, the first x-ray study cannot be made earlier than 5-6 min after the birth, i.e., at a time when in a normal birth a large amount of the pulmonary parenchyma has already expanded. Arshavskii's method is based on the following considerations: the two internal iliac or hypogastric arteries give rise to two umbilical arteries which carry venous blood to the placenta. As soon as the fetus changes over to pulmonary respiration, the blood in the umbilical arteries flowing in from the hypogastric arteries changes its gaseous composition and becomes arterial. The umbilical arteries do not close immediately; the rate of change of the gaseous composi-

tion of the blood in the umbilical arteries, i.e., the rate at which it becomes arterialized, is an indication of the rate of the transition to pulmonary gaseous exchange, and therefore of the rate of expansion of the lungs. Until now, a few authors [4-7] have studied the oxygen and carbon dioxide content in the umbilical vessels together in a single test.

In the present work we have aimed at determining changes in the gaseous composition of the blood in the umbilical arteries by withdrawing a series of blood samples from them.

As far as we know, no previous attempt has been made to use this method to determine both the composition of the blood and its changes in the umbilical arteries.

METHOD

In each infant, from 2 to 5 samples were withdrawn from the umbilical arteries. The first sample was taken 20-30 sec after birth, and the remainder at intervals of one or a few minutes. To prevent the infant from cooling, immediately after the birth it was placed in a bath filled with warm water at 37-38°. Care was taken not to compress the umbilical arteries with the hands when drawing blood. Blood samples of 2-3 cm³, which was a sufficient quantity for the main and for the repeated (control) investigations, were withdrawn into a sterile syringe having a well-ground but freely mobile piston. The blood was kept under oil in a refrigerator for 1 to 6 hr, and the blood gases were determined using the manometric model of Van Slyke's apparatus.

Blood samples from the umbilical arteries were taken from the veins of 27 normal newborn infants delivered at term in the No. 7 Grauerman Maternity Home. The results obtained are shown graphically in Fig. 1.

RESULTS

Blood samples were collected from the umbilical vein at definite time intervals from 15 children, and in

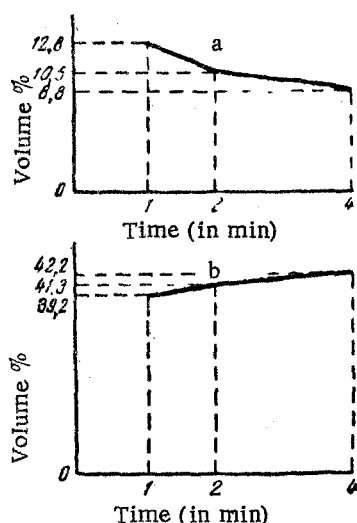


Fig. 1. Measurement of the percentage (a) oxygen and (b) carbon dioxide in the blood of the umbilical vein after birth.

12, samples were collected from the umbilical artery.

According to Barcroft [3], in normal placental gaseous exchange, the blood in the umbilical vein is 95 % saturated with oxygen. In view of the high oxygen capacity of the fetus at term, the oxygen content of the blood of the umbilical vein would be expected to lie between 19 and 20 %.

Of the 15 infants which we examined, high values of 18.8 and 17.9 % oxygen in the umbilical vein were found only in two cases. In two others, the value lay between 16.4 and 15.7 % in the first minute. In the remainder, during this time it varied from 14.3 to 9.1 %. In every case, the amount of carbon dioxide during this period varied from 37 to 45 %, and depended on the concentration of oxygen in the umbilical vein.

In every case, the newborn infant drew the first extrauterine breath, and accordingly cried, within the first minute. Our results did not allow us to determine exactly what was the oxygen content of the blood of the umbilical vein at the moment that the first breath was taken, because this event occurred during the first minute when fluctuations took place as described above. It must be emphasized that in two cases breathing started when the oxygen content in the umbilical vein was 18.8 and 17.9 %. Blood gas analyses made during the next 3-4 min showed a progressive reduction in the amount of oxygen, and, correspondingly, some increase in CO_2 . By the end of the 3-4th min, the oxygen had been reduced to 10-8 %, and in one case at the end of the fourth minute it had reached 6.1 %. Figure 1 shows a typical case of the change in oxygen and carbon dioxide contents in the blood of the umbilical vein after birth.

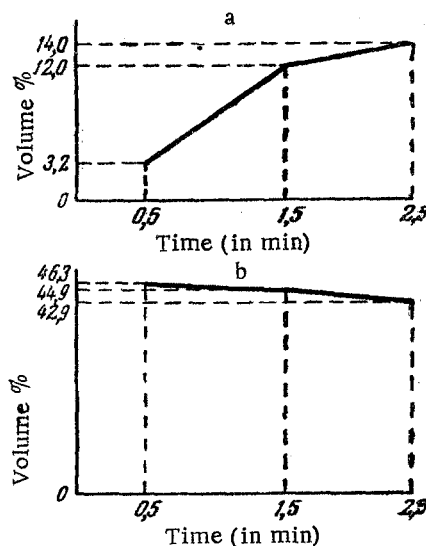


Fig. 2. Change in the percentage of (a) oxygen and (b) carbon dioxide in the blood of the umbilical artery after birth.

The progressive reduction in the oxygen content of the blood in the umbilical vein, which we found to begin after the second, and to increase rapidly after the third, minute, does not result from a cessation of placental gaseous exchange caused by separation of the placenta. The oxygen content of the blood in the umbilical vein recorded during the first minute is a reliable index of the completeness of the connection between the placenta and the uterine mucosa.

In normal newborn infants, pulsation of blood in the umbilical arteries continues during this period. On this account, the results which we obtained indicate that there is considerable variation in the extent to which the placenta has separated at birth. Thus, in cases in which the oxygen content was 18 %, it can be deduced that the birth occurred without any marked separation of the placenta. In cases where the oxygen content in the umbilical vein was 6 or 8 %, there must have been considerably more separation.

In most cases, the oxygen content in the umbilical artery varied from 3 to 6 % in the first minute, and the carbon dioxide concentration, from 45 to 48 %. In subsequent tests there was a progressive increase in blood oxygen and a corresponding decrease in carbon dioxide. Figure 2 illustrates a typical case of these blood gas changes after birth. In most cases, by the end of the third minute the blood oxygen in the umbilical artery was 12-14 %. Taking into account the oxygen capacity of the blood of the newborn child, it can be seen that the lungs are more or less fully expanded when the oxygen concentration in the umbilical artery reaches 19-20 %. It would be difficult to obtain samples of blood from

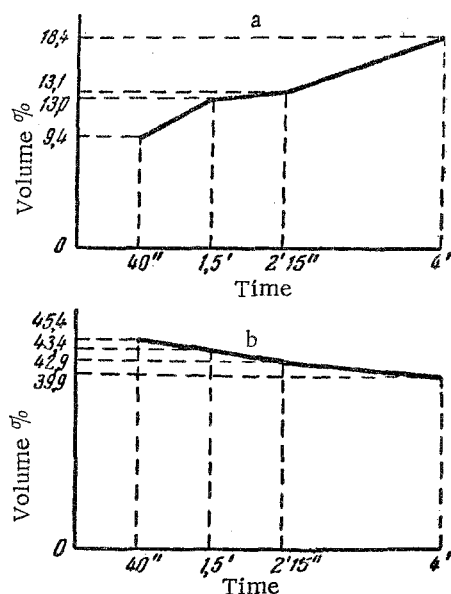


Fig. 3. Changes in the percentage oxygen content (a) and carbon dioxide (b) in the blood of the umbilical artery after birth. In this case the lungs were fully expanded at the 4th minute after birth.

these arteries 3 min after birth, not only because the artery ceases to pulsate, but because it begins to empty. In one case, blood taken at the end of the fourth minute had an oxygen content of 18.4 % (Fig. 3), indicating that the lungs were quite fully expanded. It would not be legitimate to infer that by the 4th minute, when respiratory movements are completely established, the lungs are more or less completely expanded. To establish this fact, a simultaneous x-ray examination is required. In the 27 newborn infants, the duration of the umbilical pulse was measured. In 4 it continued for 1 min, in 8 for 2 min, in 12 for 3 min, and in 3 for 4-5 min. When the pulsation in the cord ceases, the umbilical arteries empty rapidly. When this occurs it becomes increasingly difficult to withdraw blood from them. The initial closure of the umbilical arteries and their subsequent gradual emptying is probably caused by the progressive fall in the oxygen content in the umbilical vein which has been mentioned above, and which occurs approximately one minute after birth. For the same reason, the amount of blood passing into the placental capillaries is reduced. Because the amount of blood involved in

gaseous exchange with the maternal blood through the placental capillaries becomes reduced, there is naturally a progressive reduction in the oxygen content of the blood in the umbilical vein, which in this case cannot be ascribed to separation of the placenta.

Thus by measuring the oxygen and carbon dioxide contents of umbilical arterial blood in normal newborn infants by taking successive blood samples, it was shown that even 3-4 min after birth there is a marked increase in the oxygen content indicating a rapid expansion of the lungs and a transition to pulmonary gaseous exchange as the first extrauterine respiratory movements take place.

The variation of from 6 to 18.8 % in the oxygen content of the blood of the umbilical vein during the first minute indicates that there may be different degrees of separation of the placenta at birth.

SUMMARY

Measurements were made of the oxygen and carbon dioxide concentrations in successive samples of blood taken from the umbilical arteries in normal newborn infants. The oxygen content was found to rise considerably as early as the 3-4th min after birth. This points to a rapid pulmonary expansion and a changeover to gaseous exchange in normal infants performing normal initial respiratory movements. The normal range of blood oxygen concentrations within the first minute is from 6-18.8 %. This shows that in normal births labor may terminate with various degrees of placental detachment; evidently when the oxygen content was 18 %, labor terminated before detachment, while when it was only 6-8 %, the infant was delivered after the placenta had separated to a greater extent.

LITERATURE CITED

1. I. A. Arshavskii and N. E. Ozeretskovskaya, *Byull. Éksp. Biol. i Med.* 15, 42 (1943).
2. P. N. Serzhanin, *Expansion of Pulmonary Tissue in Newborn Infants as determined by X-Ray Investigations* [in Russian] (Moscow, 1958).
3. J. Barcroft, *Researches on Prenatal Life* (Oxford, 1946).
4. M. Bidone, *Ann. Ostet. Gynec.* 53, 197 (1931).
5. N. Eastman, *Bull. Johns Hopkins Hosp.* 50, 39 (1932).
6. G. Haselhorst and K. Stromberger, *Z. Geburtsh. und Gynäk.* 98, 49 (1930).
7. M. Noguchi, *Japan. J. Obst. and Gyn.* 20, 218 (1937).