

THE HUMAN PLACENTAL BARRIER AT THE END OF NORMAL AND DURING PATHOLOGICAL PREGNANCY

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By the end of normal pregnancy the epithelium covering the villi has become much thinner than in early ontogenesis. The blood vessels lie much closer to the epithelium of the villi. The dimensions of the placental barrier vary from 2.7 to 59.7 μ . In the case of intrauterine death of the fetus the syncytium becomes thinner still, most vessels lie further from the external layer of the villi, and the blood vessel wall becomes double in thickness. In this case the placental barrier measures 6.2-83.9 μ .

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The placenta is known to control the link between maternal and fetal metabolism. In this function a decisive role is played by the morphological and histochemical state of structures of the placental barrier, as they change in the course of pregnancy. However, there is still very little information in the literature on changes in the dimensions of elements of this barrier separating the maternal and fetal blood.

The present investigation is a continuation of previous work [1] devoted to the biometric analysis of the structure of the human placenta during the first third of normal pregnancy.

EXPERIMENTAL METHOD

Combined morphological and histochemical investigations were made of 130 human placentas obtained at different stages of normal pregnancy and 75 in pathological pregnancy. Pieces of the organs were embedded in paraffin wax and celloidin, and sections also were cut on a freezing microtome and in a cryostat. Serial paraffin sections were stained by the usual morphological methods and also for polysaccharides by the method of Vinogradov and Fuks [3] with all necessary controls, for nucleic acids by the methods of Fuelgen and Brachet [7], and for SH-groups by the method of Yakovlev and Nistratova [5]. Activity of phosphatases, nonspecific esterases, succinate dehydrogenase, and $\text{NAD} \cdot \text{H}_2$ - and $\text{NADP} \cdot \text{H}_2$ -diphosphorases [6] and the content of lipids and iron compounds were investigated. As a result of this preliminary morphofunctional analysis, functionally active chorionic villi typical of the clinical situations studied could be chosen for biometric investigation. Altogether 850 measurements were made on 70 villi from the human placenta of a normal 40-week pregnancy and 1060 measurements on 105 villi from the placenta of a woman whose pregnancy was terminated at 29-30 weeks by intrauterine death of the fetus. This last object was chosen because during normal pregnancy, at about 30 weeks, changes connected with physiological "aging" of the placenta are not so sharply defined, and during analysis of the changes observed it is therefore possible to examine the presence of a relationship of cause and effect between them and the fate of the fetus. The following measurements were made on the villi: the dimensions of their syncytial cover, the thickness of the wall of the fetal blood vessel lying in the stroma of the villus, and the distance from the basement membrane of the trophoblast to the outer wall of the blood vessel. The method of biometric measurements using a drawing apparatus, as described by Khvatov [4], and the writer's combination of methods of statistical analysis of the results [2] were used. Schemes of the placental barrier were constructed on the basis of arithmetic mean values (Figs. 1 and 2), the lines M - N reflecting significant

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TABLE 1. Results of Biometric Analysis of Structures of Human Placental Barrier at End of Normal Pregnancy and After Intrauterine Death of Fetus

Object measured	Dimensions (in c.u.)			Coefficient of variation (in %)		
	$M \pm m$	σ	$V_{\min} - V_{\max}$	$M \pm m$	σ	$V_{\min} - V_{\max}$
Thickness of syncytium (ac)	$12,5 \pm 0,90$ $10,1 \pm 0,44$	$\pm 4,70$ $\pm 2,17$	$5,0$ $7,1$	$17,9 \pm 1,94$ $13,0 \pm 1,19$	$\pm 9,66$ $\pm 5,93$	$3,3$ $6,2$
Distance from subepithelial membrane to outer wall of blood vessel in zone I (cd)	$5,0 \pm 0,58$ $17,0 \pm 3,57$	$\pm 2,51$ $\pm 8,75$	0 $1,5$	$37,5 \pm 5,10$ $22,7 \pm 3,34$	$\pm 22,30$ $\pm 8,20$	0 $13,9$
Distance from subepithelial membrane to outer wall of blood vessel in zone II (ce)	$26,0 \pm 7,15$ $52,1 \pm 6,56$	$\pm 17,50$ $\pm 17,30$	$9,3$ $31,3$	$23,5 \pm 4,90$ $9,8 \pm 3,22$	$\pm 12,00$ $\pm 8,51$	$6,1$ $1,0$
Distance from subepithelial membrane to outer wall of blood vessel in zone III (cf)	$85,8 \pm 3,42$ $7,3 \pm 0,58$	$\pm 4,81$ $\pm 2,54$	Vessels absent $82,4$ $1,5$	$6,2 \pm 3,26$ $22,6 \pm 2,16$	$\pm 4,59$ $\pm 9,40$	$2,9$ $9,1$
Thickness of vessel wall (fg)	$13,6 \pm 1,96$	$\pm 7,33$	$3,8$	$18,4 \pm 3,56$	$\pm 13,30$	$4,3$

Note. 1. In each horizontal column the first line contains information on the dimensions of placental structures at the end of normal pregnancy, and the second line after intrauterine death of the fetus. 2. In this investigation one conventional unit = 0.416 μ . 3. In the villi of the placenta obtained at the end of normal pregnancy no vessels are present in zone III. 4. The pattern of distribution of the vessels by zones is described in the writer's previous paper [2]. 5. After the name of the object measured, its designation on the figures is shown in parentheses.

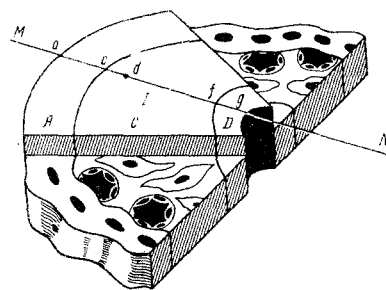


Fig. 1. Biometric scheme of human placental barrier at the 40th week of pregnancy. A) Syncytial trophoblast; C) connective-tissue part of villus; D) blood vessel wall; 1) zone with most blood vessels. Remainder of legend described in Table 1 and text.

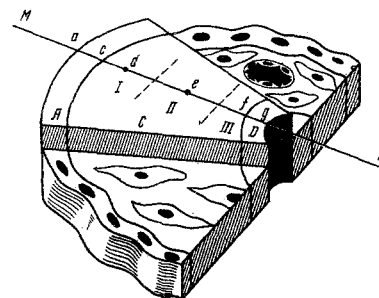


Fig. 2. Biometric scheme of human placental barrier at 30th week of pregnancy terminating in intrauterine death of fetus. I-III) Zones of blood vessels. Remainder of legend as in Fig. 1.

quantitative relationships between the structures of the chorionic villi. The results of the statistical analysis are given in Table 1.

EXPERIMENTAL RESULTS

The investigation showed that by the end of pregnancy a statistically significant decrease in thickness of the epithelium of the villi takes place by comparison with early ontogenesis [1]. This was due to two causes. First, it is at this time that the layer of Langhans disappears.

Second, in 60% of villi the syncytial cover becomes thinner than at the earlier periods of development. The coefficient of variation of this parameter also is reduced, and this may indicate more constant functional properties of the syncytium at the end of pregnancy, and also possibly a decrease in its activity. Actually, $V_{\max} : V_{\min} \approx 4$,* whereas in the first third of pregnancy this ratio equals 9.

Analysis of the distribution of blood vessels in the stroma of the villi shows that they mainly lie close to the syncytium. This period of ontogenesis is characterized by the presence of syncytio-endothelial membranes: 20% of blood vessels lie at a distance of not more than three conventional units (c.u.) from the basement membrane, 56% at a distance of between 3 and 9 c.u., and their greatest distance away is only 60 c.u. Only a few of the most distant vessels lie in the zone corresponding to zone II of their distribution in the first third of pregnancy. The blood vessels have a very thin wall. Analysis of the dimensions of all structures of the human placental barrier thus indicates that toward the end of normal pregnancy the maternal and fetal blood streams come significantly closer together. The smallest dimensions of the placental barrier average 2.7μ , and the greatest 59.7μ .

After intrauterine death of the fetus the syncytium becomes thinner, and the coefficient of variation of this characteristic is reduced, possibly indicating a decrease in its functional activity. $V_{\max} : V_{\min} \approx 2.5$. The blood vessels lie far away from the epithelium: 46.6% in zone II and 13.4% in zone III. Characteristically in preparations of this placenta very few syncytio-endothelial membranes are observed, and the wall of the central vessels is double in thickness.

These morphological features of the chorionic villi may indicate a worsening of metabolic processes between mother and fetus in connection with the increasing distance between the fetal and maternal blood streams.

It follows from these investigations that the mean minimal dimensions of the placental barrier in this case were 6.2μ , and the maximal 83.9μ .

As a result of this biometric analysis, age changes in the dimensions of structures of the chorionic villi were determined and their state assessed during pathological pregnancy, notably when accompanied by intrauterine death of the fetus. The parameters obtained for the human placental barrier can serve as the basis for a quantitative assessment of its state in any concrete clinical situation, and in conjunction with the morphological and histochemical picture of the chorionic villi, they can provide objective criteria for evaluation of the morphofunctional state of the placenta.

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* V_{\min} is the least variant, V_{\max} the greatest variant.