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The Amount of Fetal Blood Remaining in the Placenta at Birth* (33548)

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For physiologic and medical reasons it is desirable to know the amount of fetal blood which remains in the placenta and umbilical cord when they are severed from the fetus at birth. This should be an approximation of the partition of blood between fetus and placenta during undisturbed intrauterine life. Data based on weight gain of the neonate by placental transfusion as reviewed by Smith (1) and Moss and Monset-Couchard (2) agree fairly well on an amount of approximately 100 g in a full-size infant. Estimates of the amount of blood remaining in the placenta, based on the volume drained through the cord, vary from 85 to 125 ml after early clamping of the cord, and from 0 to 40 ml after late clamping (2). Smith (1) has cautioned that such amounts are not necessarily representative of the content at any moment before the onset of labor.

Since none of the reported estimates of the fetal blood content of the placenta include the amount which cannot be drained through the cord, it is desirable to obtain a direct measure of the amount of blood separated from the fetus at birth. Whole placentas were homogenized and their blood contents determined. Since the placenta also contains maternal blood, determinations were limited to fetal hemoglobin and related to the concentration in cord blood from the same specimen.

Method. After the cord was cut at delivery between clamps, the clamp on the placental side was left in place, and the entire specimen was received in a pan in which the following dissection was carried out. A sample of unclotted cord blood was diluted with 4 times its volume of water, the resulting hemolysate was centrifuged and the supernatant examined for fetal hemoglobin by the alkali denaturation method of Singer *et al.* (3). The placenta specimen including cord and blood in the pan was treated as follows. The cord was stripped until all its blood had emptied into the pan, and was discarded. The same was done with the fetal membranes beyond the margin of the placenta. In order to reduce the amount of connective tissue for subsequent homogenizing in a blendor, the chorionic plate was dissected from the placenta, (care was taken to separate all red placental tissue and to empty the large fetal

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TABLE I. Amount of Fetal Blood in Placenta and Cord.

Mode of delivery	No. of cases	Blood in placenta and cord, as percentage of			
		Body wt.		Placenta wt.	
		Mean	Range	Mean	Range
Vaginal, cord clamped promptly	62	4.5	1.5–7.6	28	8–54
Vaginal, placental transfusion	5	2.5	1.5–3.6	18	14–28
Cesarean section, no labor	13	5.2	3.5–6.9	31	22–45
Cesarean section after labor	3	4.9	3.9–5.9	29	27–31
Abortion, 83 g, hysterotomy	1		30.2		29

vessels); the chorion was then washed with water which was added to the contents of the pan, and the chorion was discarded. The pan was emptied into a plastic bag, washed with water which was added to the specimen, and the latter was weighed. The entire specimen was minced in a blendor. An aliquot of 50–100 ml was diluted with an equal amount of water and again homogenized; this was necessary to break up all villi and achieve complete hemolysis. The amount of fetal hemoglobin was then determined in a sample, and the total amount for the entire specimen was calculated. Knowing the amount of fetal hemoglobin in 1 ml of fetal (cord) blood, one could then determine the volume of fetal blood in the entire specimen. All determinations of fetal hemoglobin were done in duplicate, and a control sample of adult blood was examined with each group. Any loss of fetal blood prior to obtaining the specimen would result in an underestimate of the total amount. This was probably small because grossly lacerated placentas were excluded from study. Blood drawn from the cord for other purposes was taken into consideration.

Results. Determinations were made in 84 placentas. The amount of blood in proportion to body weight is shown in Table I and Fig. 1, and in proportion to placenta weight (trimmed, without extraneous blood) in Table I and Fig. 2. The ratio of fetal blood to placenta weight is not necessarily a measure of the blood content of the placenta itself, because it includes the often considerable amount of blood contained in the cord. The following discussions will be concerned mostly with the amount of blood expressed as percentage of body weight. One determination was made in the placenta of an 83-g fetus delivered by hysterotomy in the intact sac; this case is not included in Fig. 2. Two infants had a birth weight between 400 and 1000 g, 13 weighed between 1600 and 2500 g, and the remaining 68 weighed more than 2500 g. The difference between the mean value of 4.5% of body weight in 62 vaginal deliveries with immediate clamping of the cord, and 5.1% in 16 cesarean sections with or without labor (all with prompt clamping of the cord) is not statistically significant being less than twice the standard error of the difference.

Other conditions included, but not listed separately in Table I or Fig. 1 and 2, are: Apgar score below 7 at 1 min: the values in 4 cases ranged between 2.1 and 6.3% of body weight. Maternal diabetes, with cesarean section in 2 of 3 cases, gave values between 4.4 and 5.0%. In 1 case of abruptio placentae the amount was 3.1%. The only data suggestive of a significant trend, but too few for confident interpretation, are those in preeclampsia yielding higher values than usual. In 3 cases delivered vaginally with prompt clamping of the cord the mean was 6.2% as compared with 4.4% for the remaining 59 cases in that group; one case with placental transfusion had 3.6% against 2.2% in the remaining 4 cases.

Discussion. The present findings are of an order of magnitude which conforms with the above mentioned estimates (1,2) derived from the infant's weight gain by placental transfusion, or the amount obtained during the third stage of labor. The amount not

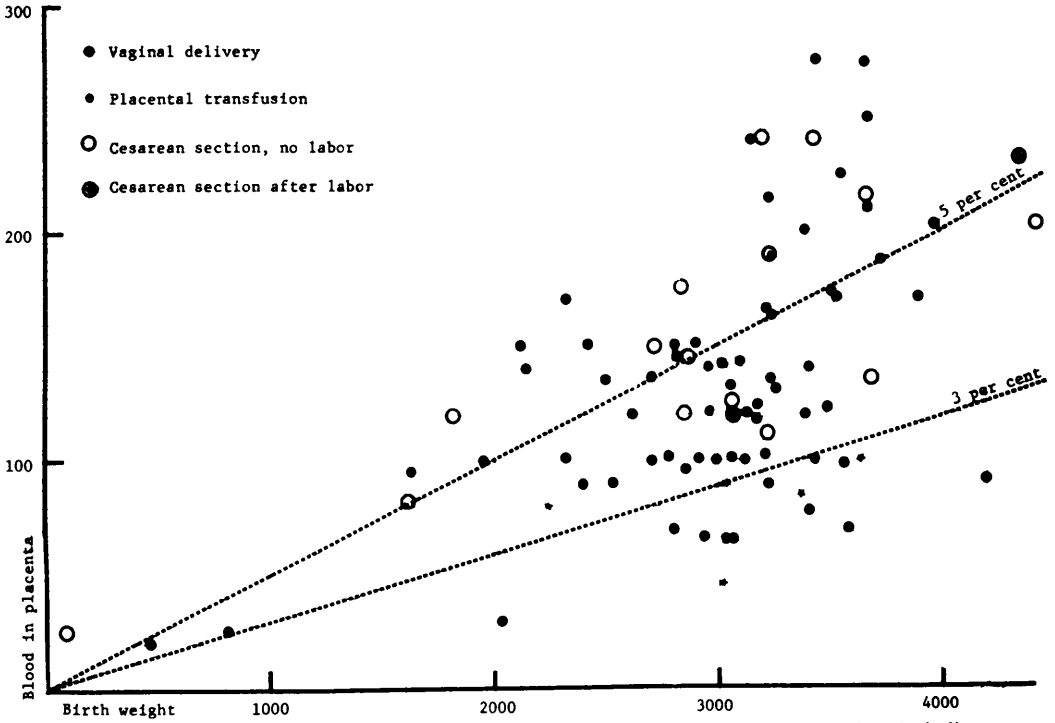

Fig. 1. Amount of fetal blood in placenta and cord plotted against birth weight: (- - -), indicates 3 and 5% of birth weight.

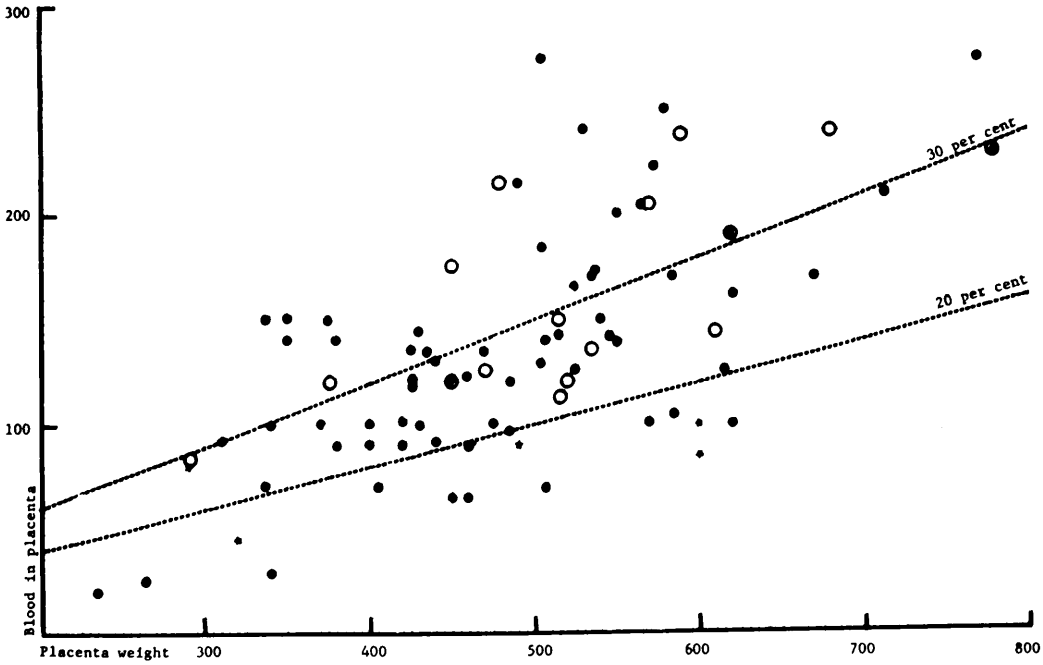

FIG. 2. Amount of fetal blood in placenta and cord plotted against placenta weight. The symbols are the same as in Fig. 1. (- - -), indicates 20 and 30% of placenta weight.

recoverable by transfusion had not been known. If the data in Table I should be confirmed by a larger number of determinations following placental transfusion, they would indicate that about half the amount was not transfused, but these transfusions were probably not as complete as those performed by others (1) for the purpose of ascertaining the maximal amount obtainable.

The great variation of blood content of the placenta (Figs. 1, 2) is unexplained. It may relate to the known reactivity of the placental vasculature to hypoxia (4) or drugs (5) that may have been present just before delivery, perhaps only for a short time. In maternal preeclampsia when the maternal blood flow to the placenta is reduced, the fetal vessels may be dilated as suggested by the larger amount of blood; this would agree with an effect of hypoxia. The range of values is wider among vaginal deliveries with prompt clamping of the cord than among cesarean sections (Table I).

Specimens from cesarean sections, particularly those done not in labor, may be more nearly representative of the undisturbed state *in utero* than those from vaginal deliveries. The amount of blood in the former is slightly higher than in the latter. The narrower range of values in cesarean section is in accord with the suggestion made above, that some of the variation in the other group arises during labor. If the values obtained approximate conditions *in utero* prior to the onset of labor, and if the blood volume of the neonate is estimated to be 10% of its body weight, the placenta and cord contain on the average one-third of the blood volume *in utero*. DeMarsh *et al.* (6) estimated, on the basis of the amount of blood drained from the placenta through the cord, that this proportion is 26–34%. If it were true that conditions shortly before birth produce variations in the partition of blood between fetus and placenta, these conditions should be studied and taken into account particularly when the question of placental transfusion arises.

How the fetal heart can cope with the burden of placental circulation without hypertrophy to a larger relative size, is perhaps explained by the fact that the right and left ventricles operate largely parallel and thus share the work of propelling the systemic circulation to which the placenta is attached. The change-over of circulation at birth to operation of the ventricles in series emphasizes the need to give consideration to the additional load imposed upon the infant by placental transfusion. It has been surmised that the advantages or hazards of such transfusion are different in premature infants. The present data include 15 infants of low birth weight (apart from the 83-g fetus) and there is no indication that the proportion of blood in the placenta of these infants differs from that in full-size ones to a significant extent, being 5.0% of body weight.

Summary. The amount of fetal blood remaining in placenta and cord has been determined in 84 births, making use of the total amount of fetal hemoglobin in relation to its concentration in cord blood of the same infant. Expressed as percentage of body weight, the amount is 4.5 in 62 vaginal deliveries with prompt clamping of the cord, 2.5 in 5 cases of placental transfusion, and 5.1 in 16 cesarean sections. In 4 cases of preeclampsia the amount is markedly greater than in other comparable births. The possibility is suggested that events shortly before birth, perhaps during the second stage of labor, influence the partition of blood between fetus and placenta.

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