

## Estimation of Water Transfer from Amniotic Fluid to Fetus.\* (22511)

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The average exchange rate of water between amniotic fluid and maternal system including the fetus amounts to about 27 mols per hour(1). The pathway and mechanism of this exchange is unknown and it is not clear whether the fetus participates to any appreciable degree. If the fetus plays a major role in the transfer of water from amniotic fluid to mother, the treatment of experimental data must provide for this by its inclusion as a separate, third compartment. The theoretic background for such a multi-compartment system in which an exchange takes place between all of them, has been given previously, where a hydrodynamic model was used to demonstrate how transfer rates can be calculated from time activity curves.

The human fetus is inaccessible during pregnancy and samples of fetal body fluids can only be obtained at the termination of the experiment, *i.e.*, at delivery. Since the change in tracer concentration as a function of time follows a double exponential curve for all 3 compartments, a single value for the fetal compartment is not sufficient to calculate transfer rates. A rough estimate of one of these transfer rates can be made from the observation that the time activity curves for the fetus pass through a maximum. The present experiments with hydrodynamic models, analogous to the biologic system, were carried out in an effort to estimate the quantity of water passing from amniotic fluid to fetus per unit time.

**Methods.** A. *Hydrodynamic models.* The apparatus was essentially that described by Plentl and Gray(2). Amniotic fluid-, maternal-, and fetal compartments were represented by glass tanks containing 1,500, 30,000 and 1,500 ml of water. Six small laboratory

pumps were used to transfer the water in the 6 possible directions. "Time activity" curves were obtained by following the change in concentration of a dye added to the amniotic fluid compartment. A series of experiments was then carried out by varying the transfer rates from the amniotic fluid to the other 2 compartments (mother and fetus) but keeping their sum constant. The rates were so adjusted that a total of 500 ml entered and left the amniotic fluid compartment per hour. In 4 representative experiments 25, 50, 75 and 100% of this amount passed from amniotic fluid to fetus. The remaining transfer rates were changed slightly in each experiment so as to keep the system in a steady state. B. *Clinical.* Total body water determinations were carried out on pregnant volunteers at term 2 days before carrying out the experiments. All patients had been admitted for elective Cesarean section. On the day of the operation a trans-abdominal amniotomy was performed by a technic previously described(3). An accurately known amount of deuterium oxide was then introduced into the amniotic sac after a control sample of amniotic fluid and maternal blood was taken. The tracer and amniotic fluid were then thoroughly mixed by frequent withdrawal and reintroduction of the fluid, change in the position of the patient and massage. At the time of section samples of maternal serum, amniotic fluid and cord blood were obtained. These were analyzed for their deuterium oxide content using the falling drop technic.

**Results.** The exchange rate between fetus and mother is probably in the neighborhood of 2,000 to 3,000 ml per hour and the amount of water entering and leaving the amniotic fluid is known to be about 500 ml per hour (4). The water can be transferred from the amniotic fluid to the mother or the fetus or both. When the contribution to each of these compartments was varied only minor differ-

\* This investigation was in part supported by Grants-in-aid of Ortho Research Foundation, N.I.H., Department of Health, Education and Welfare under Grant No. RG-3354(C3).

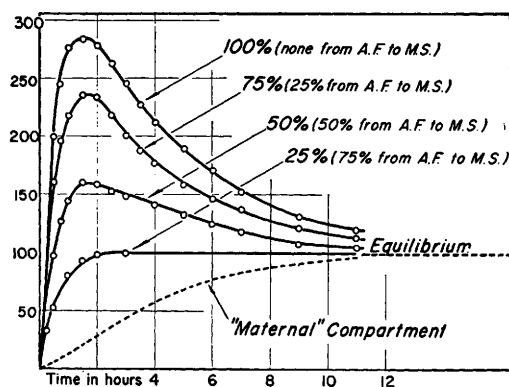


FIG. 1. Time activity curves for the fetal compartment obtained on hydrodynamic models under conditions described in the text. Total amount entering and leaving amniotic fluid compartment remained constant but percentage passing through fetus varied as indicated.

ences were noted in the time activity curves for amniotic fluid and maternal systems but an appreciable variation was observed for the fetal compartment. No matter how the other transfer rates were varied the time activity curves for the fetus never exceeded the equilibrium value if less than 25% of the amount leaving the amniotic fluid went through the fetus. The fetal curves invariably passed through a maximum when more than a quarter of the transfer took this route. The results are recorded graphically in Fig. 1.

During previous investigations on the water transfer in this system the clinical experiments were carried out over as long a period as possible. Hourly samples of amniotic fluid and maternal blood were collected over periods of at least 6, usually 10 hours. The concentrations of deuterium oxide in cord blood and

maternal system at the end of this time were always identical, an expected finding in view of the rapid exchange of water across the placenta.

The present experiments were of much shorter duration. The Cesarean sections were carried out within 15 to 60 minutes after the introduction of deuterium oxide into the amniotic fluid compartment. The results on 5 of these experiments are reproduced in Table I. The deuterium oxide concentration in cord blood invariably exceeded the calculated equilibrium value by 25 to 250%. Since the time concentration curve for the fetus eventually approaches the equilibrium value, this curve must pass through a maximum. In the light of the observations on hydrodynamic models described above, this must be interpreted as evidence that a minimum of 25% and probably more than 50% of the water transfer from amniotic fluid to mother is accomplished through the intermedium of the fetus.

**Summary.** Deuterium oxide was injected into the amniotic sac of pregnant women one hour or less before delivery by Cesarean section. The tracer concentration in cord blood invariably exceeded the calculated equilibrium value. This observation led to the conclusion that time activity curves for the fetal compartment must pass through a maximum. On the basis of experiments with hydrodynamic models this was interpreted to mean that at least 25%, probably more than 50% of the water transfer from the amniotic fluid to mother is accomplished through the intermedium of the fetus.

TABLE I. Summary of Results Obtained in 5 Normal Patients. Cesarean section was performed within a period of one hr after amniotomy.

| Elapsed time after inj. of D <sub>2</sub> O into AF (min.) | AF vol (ml) | Calc. equil. value (% D <sub>2</sub> O) | % equilibrium value |            |
|------------------------------------------------------------|-------------|-----------------------------------------|---------------------|------------|
|                                                            |             |                                         | Maternal serum      | Cord blood |
| 20                                                         | 790         | .123                                    | 7                   | 236        |
| 22                                                         | 1130        | .129                                    | 9                   | 123        |
| 25                                                         | 660         | .118                                    | 17                  | 204        |
| 50                                                         | 690         | .158                                    | 40                  | 155        |
| 60                                                         | 500         | .205                                    | 33                  | 350        |

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Received May 11, 1956. P.S.E.B.M., 1956, v92.