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Growth of Uterine, Placental and Fetal Vasculature

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I. Abstract

A technique to measure organ blood flow and its distribution with the use of radioactive microspheres has been developed in our laboratory. This method of blood flow determination is useful in organs with multiple arterial supply and venous drainage in which case flowmeters are impractical and the application of Fick's principle may be hampered by the inequality of concentration of the test substance in the venous outputs. The microsphere method has been applied to the study of uterine blood flow in pregnant sheep and the estimation of fetal cerebral blood flow.

II. Final Report

A method utilizing radioactive microspheres was developed in our laboratory to measure organ blood flow and its distribution. The microsphere technique has been compared with the steady-state diffusion method and electromagnetic flow probes and shows excellent correlation. This technique has been used to measure uterine and umbilical blood flows and their distribution in pregnant sheep. In the last 30 days of pregnancy in the sheep we have demonstrated that 84% of total uterine blood flow is distributed to the placenta, 13% to the endometrium and 3% to the myometrium. Furthermore, 94% of umbilical blood flow is distributed to the placenta and 6% to the intercotyledonary chorion. Studies on the macroscopic distribution of the uterine and umbilical blood flows in sheep show an uneven distribution of 1 to 3%.

These studies contribute to a basic understanding of the efficiency of the placenta as a concurrent exchange system. Previous studies in our laboratory, using the steady-state diffusion method, have shown an inequality of the concentrations of antipyrine in the main uterine and umbilical veins. The umbilical vein to uterine vein concentration difference averages 18% of the umbilical artery to uterine artery difference. From the studies on the distribution of umbilical and uterine flows by the microsphere method, we were able to calculate the venous admixture of cotyledonary with non cotyledonary blood in both uterine and umbilical circulations as well as the degree of uneven distribution. Such calculations

show that 60% of the umbilical vein to uterine vein concentration difference may be due to the venous admixture of cotyledonary with non cotyledonary blood and to uneven distribution.

More recently the microsphere technique has been applied to measure cerebral blood flow of fetal lambs in utero. Polyvinyl catheters were inserted into a fetal pedal vein, both transverse scapular arteries for a distance of 4.0 cm which placed the catheter tip just inside the innominate artery without obstructing the blood flow through the carotid arteries and the sagittal sinus of 11 fetuses during the last month of pregnancy. Cerebral blood flow, oxygen consumption and glucose utilization were determined 24 to 72 hours post operatively with the ewe standing quietly in a crate. The mean cerebral blood flow was 120.6 ± 8.7 ml/100 gm/min. The mean percent distribution of cephalic flow to the brain, eyes, skin and remainder of cephalic tissues were 37.6, 40, 12.3 and 46.1 respectively. The mean cerebral oxygen consumption was 4.04 ± 0.17 ml/100 gm/min and the mean cerebral glucose utilization was 5.31 ± 0.42 mg/100 gm/min. The mean glucose/oxygen quotient was 1.10.

Previous studies have measured carotid blood flows in fetal and newborn lambs and inferences have been drawn from these measurements concerning cerebral blood flow. It can be seen from our data that the cerebral blood flow of fetal lambs is approximately 38% of the cephalic flow. This fact and the existence of marked differences in the regulation of flows to different organs and tissues of the body suggest that changes in carotid

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flow may not be a reliable index of changes in cerebral flow.

The mean fetal cerebral blood flow observed by us is much higher than the cerebral blood flow of adult animals. The much higher cerebral flow of fetal life is probably due to the fact that fetal carotid blood is much less oxygenated and has a higher P_{CO_2} than the normal arterial blood of adult animals.

The measurements of fetal cerebral oxygen and glucose uptakes in this study represent the first estimates of these variables in nonexteriorized fetuses. These results are comparable to those observed in the brain of adult animals and indicate the existence of a low margin of safety with respect to an adequate supply of oxygen and glucose to the fetal brain since the oxygen and glucose contents of the arterial blood perfusing the fetal head are considerably less than in the adult animal.

A. Publications

1. Distribution of Uterine Blood Flow in the Pregnant Sheep.

E. L. Makowski, G. Meschia, W. Droegemueller and
F. C. Battaglia: Amer. J. Obst. and Gynec., 101:409-
412, 1968.

2. Measurement of Umbilical Arterial Blood Flow to the Sheep Placenta and Fetus in Utero. E. L. Makowski, G. Meschia, W. Droegemueller and F. C. Battaglia: Circ. Res., 23:623-631, 1968.

3. Macroscopic Distribution of Blood Flow in the Sheep Placenta. J. Rankin, G. Meschia, E. L. Makowski and F. C. Battaglia: Amer. J. Physiol., 219:9-16, 1970.
4. Cerebral Blood Flow, Oxygen Consumption, and Glucose Utilization of Fetal Lambs in Utero. E. L. Makowski, J. M. Schneider, N. G. Tsoulos, J. R. Colwill, F. C. Battaglia, and G. Meschia: Amer. J. Obst. and Gynec., 114:292-303, 1972.