Effects of Obstetric Anesthesia on the Fetus and Newborn

By M. Finster

Almost every drug used in obstetrical analgesia and anesthesia has been found to cross the placenta, in most instances by simple diffusion. This process is influenced by several factors:

a) Degree of ionization: Organic drugs are transferred mainly in the undissociated or non-ionized form; charged or ionized particles penetrate with difficulty. Changes in pH which increase the concentration of the undissociated form therefore favor the passage of drugs into the fetus.

b) The degree of fat solubility of the non-ionized molecule probably plays the most important role in governing the rate of transfer across the placenta. Drugs with high fat solubility are transferred rapidly, whereas lipid insoluble drugs penetrate poorly.

c) The concentration gradient which is related primarily to the quantity of drug administered to the mother, the route of administration and the state of uterine and fetal circulations.

d) Substances of low molecular weight diffuse freely across the placenta, whereas those of molecular weight exceeding 1000 do not cross at all.

Once the drug reaches the fetal side of the placenta, the response of the infant is related to the quantity of drug which reaches its central nervous system. The fact that anesthetized mothers usually deliver vigorous infants indicates that there is a delay in the uptake of anesthetic drugs by the fetal brain and other tissues. The reason for the delay is that, unlike maternal tissues, which are in direct contact with maternal blood, fetal tissues are separated from maternal blood by another compartment, namely fetal blood. Although significant concentrations of various anesthetic drugs have been found in umbilical vein blood shortly after their administration to the mother, unique characteristics of the fetal circulation protect the fetus from their immediate effect.

Blood returns from the placenta to the fetus via the umbilical vein, which enters the fetal liver and is joined by the portal vein. Most of the umbilical vein blood perfuses the hepatic parenchyma and enters the inferior vena cava through the hepatic vein, while a small proportion is shunted through the ductus venosus directly into the inferior vena cava. Consequently the greater portion of any drug is strained through the liver before gaining access to the rest of the fetus. Substantial hepatic accumulation of anesthetic agents such as thiopental, halothane and lidocaine has indeed been de-
monstrated. The liver is thus seen to occupy a vital vascular crossroad in the fetal circulation, decreasing the amount of lipid soluble drugs reaching the central nervous system and other vital organs of the fetus.

The contents of the inferior vena cava above the hepatic vein consist of an admixture of arterialized blood from the placenta with venous blood returning from the gastrointestinal tract and the lower extremities. This mixed caval blood divides into two streams. The smaller one, amounting to about 40% of the inferior caval flow, enters the right heart where it becomes further admixed with venous blood returning via the superior vena cava from the brain, head and upper extremities. This blood is ejected by the right ventricle into the pulmonary trunk, but only a small fraction actually perfuses the fetal lungs, since the major portion is shunted into the thoracic aorta through the ductus arteriosus. The remaining 60% of the blood flowing up the inferior vena cava traverses the foramen ovale into the left atrium where it undergoes admixture with blood returning from the lungs. This blood is then ejected into the aorta and delivered to the head and upper extremities, to the trunk and lower extremities and, via the umbilical arteries, to the placenta. Because of the pattern of fetal circulation described above any drug which crosses the placenta must undergo progressive dilution within the fetus before it reaches the arterial side of the fetal circulation.

During labor, uterine contractions may reduce the amount of drugs transmitted to the fetus by decreasing the perfusion of the intervillous space of the placenta. Finally, cord compression, which has been found to occur in approximately 1/3 of vaginal deliveries, may also impede free entry of drugs into the fetal circulation.

It should be emphasized, however, that the fetal "protection" from drugs administered to the mother is only temporary. Prolonged anesthesia and/or the administration of large doses of depressant drugs to the mother will inevitably increase the incidence of depression in the newborn. SHNIDER and MOYA found that infants delivered in less than 1 h following intramuscular doses of 50, 75 or 100 mg of meperidine to the mother were not depressed by the drug, whereas if delivery was delayed beyond 1 h, a certain proportion of the infants were affected (one-minute Apgar score of 6 or less). Similarly, with cyclopropane anesthesia for elective cesarean section, MOYA observed depression attributable to the anesthetic only in infants delivered after more than 5-6 min of anesthesia. For anesthetic concentrations of nitrous oxide, the critical period appears to be 10 min. In the case of thiopental, we have confirmed the absence of fetal and neonatal depression following low doses (less than 7 mg/kg to the mother); infants delivered between 3 and 7 min after larger doses (8 mg/kg) tended to show some barbiturate-induced depression, indicated by lower Apgar scores.

The use of local anesthetic techniques in obstetrics has several advantages over general anesthesia. It provides the mother with excellent relief of pain