Title : MEASUREMENT OF CEREBRAL BLOOD FLOW IN CHILDREN

Authors : D. B. Swedlow, M.D. and L. E. Lewis, B.S.

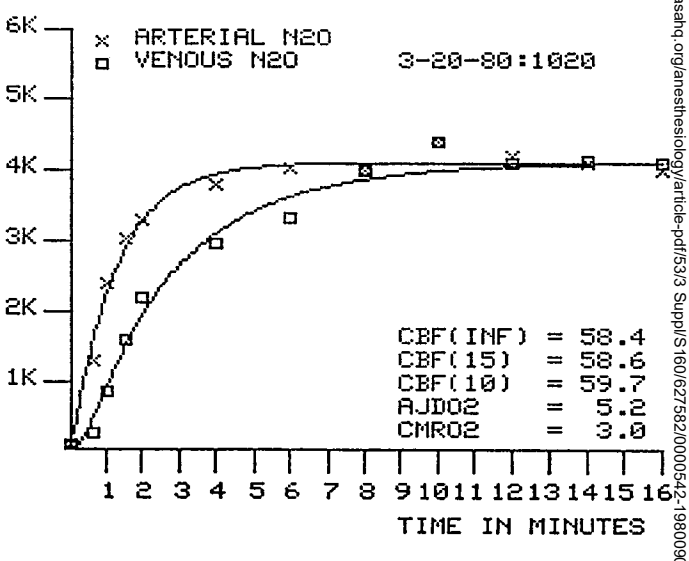
Affiliation: Departments of Anesthesia, The Children's Hospital of Philadelphia and The University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania 19104

Introduction. Global cerebral blood flow was first measured by Kety and Schmidt using nitrous oxide[1]. Using a modification of the Fick principle, they administered N_2O to patients while sampling blood from a systemic artery and jugular vein. Plotting the arterial and venous concentrations of N_2O against time, they estimated the CBF. With simultaneous arterial and venous oxygen content measurements, global cerebral metabolic rate for oxygen ($CMRO_2$) was calculated. Since then, a variety of techniques have been developed using radioisotopes[2] or mass spectrometry[3] with inert gases. The difficulty of analyzing small samples of blood for N_2O content has led to the abandonment of N_2O as the trace gas despite its safety and ease of administration. We developed a method of measuring N_2O in small volumes of blood to permit CBF and $CMRO_2$ determinations in children and infants.

Method. Following percutaneous internal jugular vein cannulation, a teflon catheter is threaded retrograde to the internal jugular bulb. A systemic artery is cannulated in the usual fashion. Simultaneous samples of jugular venous and arterial blood are obtained for O_2 content determination in $cc O_2/dl$. N_2O (10%) is administered via an endotracheal tube or tight-fitting face mask. At appropriate intervals, 0.2 cc aliquots of blood are drawn into preheparinized, dried, self-evacuating syringes to avoid dilutional and aerobic artifacts. Blood is transferred to disposable test chambers with a Hamilton syringe. Blood-to-gas extraction of N_2O from the sample is achieved by continuously recirculating gas between the test chamber and a Foregger infrared N_2O analyzer. The large gas-to-blood volume ratio and the low solubility of N_2O in blood assure complete gas extraction. CBF is computed using the modified Fick equation:

$$CBF = \frac{100 \cdot \lambda \cdot V(t)}{\int (a - v)\, dt} \quad cc/100\ gm/min$$

where λ is the brain:blood solubility coefficient, V(t) is the venous N_2O reading at saturation and $\int (a - v)\, dt$ is the area circumscribed by the arterial and venous curves. Multiplying the CBF by the O_2 content difference across the brain yields the $CMRO_2$ in measurement (r=0.998). We have successfully performed 15 cerebral blood flow and $CMRO_2$ measurements to date in 8 children: 6 with metabolic encephalopathy (Reye's Syndrome) and 2 with severe head trauma. There have been no complications resulting from the catheters or N_2O administration. A representative study is shown:



Discussion. N_2O is safe and only 5 cc of blood are required for a CBF measurement, making it practical in infants and children. No radioactive isotopes are needed. The N_2O analyzer is widely available and inexpensive compared to mass spectrometers and scintillation counters. The measurement can be performed in the intensive care unit and results are available within 45 minutes, allowing use of the data in changing clinical circumstances.

References.

1. Kety SS and Schmidt CF: The nitrous oxide method for the quantitative determination of cerebral blood flow in man; theory, procedure and normal values. J.Clin. Invest. 27:476-483, 1948

2. Lasson N and Klee A: Cerebral blood flow determined by saturation and desaturation with Krypton (85). Circ. Res. 16:26-32, 1965

3. Hass WK, Siew FP, and Yee DJ: Progress and adaptation of mass spectrometer to study of human cerebral blood flow. Circulation 38:Suppl. 6, p. 94, 1968