Severe Anemia in Childhood Presenting as Transient Ischemic Attacks

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TRANSIENT ISCHEMIC ATTACKS (TIAs) may result from interruptions in the supply of oxygen to the brain.[1] We recently cared for a child whose first manifestation of profound anemia was recurrent TIAs.

Case Report

This 2 year old girl was well until she awoke from a nap with left sided weakness. She was alert and aware of her deficit. Speech was not impaired. She was seen that afternoon by her pediatrician, but the hemiparesis (which lasted 15 minutes) had remitted by the time of examination. On the next day, she had a second 15 minute episode of left hemiparesis again following a nap. On the third day, she had another episode of left sided weakness and was hospitalized. Laboratory tests revealed severe normochromic, normocytic anemia (hemoglobin, 4 grams/dl; MCV, 82 FL; MCH, 29.7 PG; MCHC, 35.6%; reticulocyte count, 0.1%) while the white blood cell count, platelet count, and plasma glucose concentration were normal. She was transferred to The Milton S. Hershey Medical Center. The physical examination revealed an alert, but pale child; neurological examination was entirely normal. A bone marrow aspirate was hypocellular with virtual absence of red cell precursors. A diagnosis of transient erythroblastopenia of childhood was made on the basis of her age, normal hemoglobin F, and absence of erythrocyte i antigen.[2] The patient received packed red blood cell transfusions and had no subsequent attacks of weakness. Right carotid arteriogram, EEG and CT brain scan were normal. She was treated with prednisone for two weeks. A repeat bone marrow aspirate showed increased erythroid precursors. Her hematocrit returned to normal levels within one month. Neurological examination 6 months later was normal.

Discussion

Anemic hypoxia is of particular interest since Brierley has suggested that it never causes brain damage.[3] Moreover, we could not find a previous detailed report associating profound anemia with transient ischemic attacks or cerebral infarction.

It appears likely that this child's transient hemiparesis were due to anemic hypoxia. Hypothetical calculations[4–7] show that her brain oxygen requirement of approximately 50 ml_{O_2}/min (equation 1, fig. 1) was not being met (equations 2 and 3, fig. 1). These calculations assume that cerebral blood flow was near maximum, that oxygen extraction by the tissues was complete, that cardiac output was not compromised, and that PaO_2 and hemoglobin saturation were normal. Any reduction of these parameters would have further compromised delivery of oxygen. Since the brain of a child less than four years of age may use up to 50% of the oxygen breathed,[8] a four-fold reduction in hemoglobin levels could exhaust the margin of safety inherent in the oxygen transport system. It is possible that all three attacks began while she was asleep, because of the blunting of ventilatory drive and the increase in brain oxygen consumption which occurs during sleep.[9] It remains uncertain how widespread metabolic defi-

1. Brain Oxygen Requirement
   = Cerebral metabolic rate$_{O_2}$ (ml_{O_2}/g_{brain}/min) × brain weight (g)
   = 0.05 × 1,000
   = **50 ml_{O_2}/min.**

2. Arterial Oxygen Content
   = $Oxygen_{Hgb\text{-}bound}$ + $Oxygen_{dissolved}$
   = [Hgb (g/ml_{blood}) × O_2 carrying capacity of Hgb (ml_{O_2}/g_{Hgb}) × O_2 Sat.] + [ml_{O_2}/ml_{blood} × mm Hg]
   = 0.04 × 1.39 × 0.975] + [0.00003 × 100]
   = 0.0542 + 0.003
   = **0.0572 ml_{O_2}/ml_{blood}**

3. Total Oxygen Delivered to Brain
   = Cerebral Blood Flow (ml_{blood}/g_{brain}/min) × Brain Weight (g) × Arterial Oxygen Content (ml_{O_2}/ml_{blood})
   = 0.75 × 1000 × 0.0572
   = **42.9 ml_{O_2}/min**

FIGURE 1. *The patient's profound anemia causes a reduction in arterial oxygen content (Equation 2). The total amount of oxygen delivered to the brain (Equation 3) is therefore lower than the brain oxygen requirement (Equation 1).*

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ciency produces focal neurological deficits. However, hemiplegia may result from an insufficient supply of glucose[10] as well as oxygen.

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Continuous Measurement of Regional Cerebral Blood Flow Using Krypton-81m

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SUMMARY **We have developed a new method for taking continuous measurements of rCBF by means of continuous infusion of ^{81m}Kr. Using this method, it is possible to follow the sequential changes in blood flow of various brain regions continuously. The method makes it possible to observe the sequential changes in CBF following drug administration, motor activation and various kinds of stimulation, and, furthermore, to observe the CO_2 reactivity and autoregulation of cerebral vessels. It will undoubtedly prove useful in the investigation of various pathological states.**

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MOST OF THE CLINICAL METHODS FOR MEASURING cerebral blood flow (CBF) are based upon radioisotope (RI) clearance method. Consequently, in so far as it is possible to measure the absolute value of CBF, it is impossible to measure extremely short period changes. Furthermore, there are currently no clinical methods for obtaining sequential changes in rCBF continuously. We have therefore used the method for CBF measurement using ^{81m}Kr, as developed by Fasio et al.,[2] in the development of a new technique which allows for continuous recording of the regional dynamic changes in CBF over extremely short periods of time.

Method

Kr-81m solution was produced by pathing 5% glucose solution through a 10mCi Rb-Kr generator (Japan Mediphysics Co). The solution, with constant concentration, was infused continuously to the internal carotid artery (ICA) at a constant rate of 3ml/min through a catheter inserted into the ICA using a perfusion pump (Truth A-II). Under these conditions, lateral image of the head and neck were obtained by a γ-camera (Toshiba GCA 301). The obtained images were fed online into a data processor (Toshiba GNS 80A). Sampling time was 30 seconds a frame and 60 frames of the sequential data obtained every 30 seconds were collected in 30 minutes.

Theoretical Consideration

In the intracarotid Kr-81m infusion method, regional radioactivity of the brain can be obtained from the following equation:[1, 5]

$$Cieq \propto fi/(\mu + fi/vi \cdot \lambda i) \qquad (1)$$

where, Cieq is the regional radioactivity obtained from the surface of the skull, fi is the regional CBF, μ is the decay constant, vi is the volume of brain tissue perfused by radioisotope, λi is the partition coefficient between blood and tissue.

Since the half-life of ^{81m}Kr is as short as 13 seconds, the regional radioactivity (Cieq) is roughly proportional to rCBF (fi). Consequently, the equilibrium image of the brain infused with ^{81m}Kr is said to express this regional distribution of CBF. However, in the case of

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Severe anemia in childhood presenting as transient ischemic attacks.

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Background: Ischemic stroke in children can present with an epileptic seizure or be initially asymptomatic. The median time to diagnosis is 24 hours. Methods: This review is based on a selective literature search, with additional consideration of published guidelines and the authorsâ€™ personal experience. Results: In Europe and the USA, the combined incidence of ischemic and hemorrhagic stroke in childhood is 2.5 to 10 per 100 000 children per year. 40% of ischemic strokes in childhood occur after an infectious illness or in association with a congenital heart defect, sickle-cell anemia, or a c