METHAEMOGLOBINAEMIA DUE TO NITRATES AND NITRITES IN DRINKING-WATER

BY

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Methaemoglobin may be present to a small extent in the blood of normal persons, the actual range found depending to some extent on the method of estimation employed. Bodansky and Bodansky (1952) quoted values ranging from 0.6 to 1.8% of the total haemoglobin (average 1.28%), using a gasometric method, while the more usual spectrophotometric method, after conversion by NaCN to cyanmethaemoglobin, gave the much lower range of 0 to 1.1% (average 0.4%). The level at which cyanosis becomes apparent will depend on the haemoglobin concentration of the patient, being obviously more apt to occur if the total available haemoglobin is low. The condition is exacerbated by anything which increases oxygen consumption, such as heavy exercise or pyrexia.

Apart from the congenital condition of familial idiopathic methaemoglobinaemia, described by Breakey *et al.* (1951) and Codounis (1952), in which cyanosis is usually present from birth, methaemoglobinaemia may be acquired by the ingestion of a number of substances, both organic and inorganic. Nitrites in drinking-water are a possible source which may be easily overlooked. Nitrates can also cause the condition by being converted to nitrites by intestinal bacteria. Campbell (1952) reported from Northern Ireland a case of cyanosis in a 1-month-old infant due to nitrates in the water used to make up its feeds. Recognition in infants of cyanosis due to methaemoglobin formation is important, as the case may be initially mistaken for one of congenital heart disease.

A similar case recently occurred locally in a 5-weeks-old girl, also due to nitrates (and some nitrites) in the well-water used for making up feeds. It would seem that a pyrexia initiated the attack of cyanosis in this case. A further point of interest is that the mother and two elder children, who had all been drinking the same water for over a year, suffered no ill effects as a consequence, although they all showed significant amounts of methaemoglobin in their blood. The case reported by Campbell responded well to large doses of ascorbic acid, and the same treatment was applied here with satisfactory results.

Case History

The patient, an infant girl aged 5 weeks, was the youngest of a family of three children (the other two children were both well). Her birth weight was 6½ lb. (2.8 kg.). The delivery was normal. The child was said to have been slightly cyanosed at birth and jaundiced from the third to the tenth day. Progress was otherwise satisfactory. She was breast-fed for the first month, and then, as breast milk failed, placed on a four-hourly feed of 3 oz. (85 g.) of full-cream national dried milk, with 1½ dr. (6 g.) of sugar in 3½ oz. (100 ml.) of water. Owing to the housing shortage the family were obliged to live in a caravan, and the water was obtained from a near-by well. She had been on this artificial feed for approximately one week prior to admission. Three days before admission she became pale and

feverish, and then cyanosed. She was admitted to hospital on July 22, 1953.

On examination her general development was fair. She was severely cyanosed and crying. Her temperature was 102° F. (38.9° C.), pulse 148, and respirations 50. The heart sounds were normal; no murmurs. There was nothing abnormal in the chest, abdomen, mouth, throat, and ears. Blood: haemoglobin, 93%; white cells, 16,600 per c.mm. (54% polymorphs). In view of the cyanosis the child was placed in an oxygen tent, but without improvement. She also received penicillin, 125,000 units six-hourly. X-ray examination of the heart and lungs showed no physical abnormalities, which, together with the absence of physical signs, made it necessary to look for some cause of the cyanosis other than a cardiac or respiratory lesion. Initial spectroscopic examination of the blood revealed the presence of methaemoglobin. Photometric estimation showed the amount to be 56.8% of the total pigment.

The child was put on ascorbic acid, 1,000 mg. daily by mouth for three days. Within 48 hours the cyanosis had completely disappeared, her temperature had returned to normal, and she was taking her feeds quite well. Repeated blood examination three days later showed no methaemoglobin present.

While the child was in hospital, the possible cause of the methaemoglobinaemia was investigated. Poisoning by drugs, etc., likely to cause methaemoglobin formation and ingestion of aniline dyes—for example, by absorption from napkins—both seemed very improbable after questioning the mother. A sample of well-water used for making up the feeds was collected and analysed. The result showed the presence of excessive nitrate and some preformed nitrite (Table I).

TABLE I.—Analysis of the Well-waters (Parts per 100,000)

	Caravan Well		Inn Well
	10/7/53	10/12/53	
Free and saline ammonia ..	0.01	0.043	0.003
Albuminoid ammonia ..	0.005	0.01	0.01
Nitric nitrogen (nitrates) ..	7.8	7.2	3.5
Nitrous " (nitrites) ..	0.02	0.08	Trace
Oxygen absorption test ..	0.17	0.33	0.07
Toxic metals ..	None detected		

The infant was discharged a week later, July 10. The mother was advised to find an alternative supply of water and report back with her on July 28. Unfortunately the next supply of water was drawn from a near-by inn, which also used a well. This water, although rather better than the previous well-water, had considerable excess of nitrate and traces of nitrite (Table I).

On July 24 the mother reported the child to be cyanosed again. This time, however, cyanosis was less marked, and occurred chiefly in the evenings. It was not feasible to re-examine the child's blood for methaemoglobin, but as the cause was now known the mother was given a supply of ascorbic acid, the dosage to be 500 mg. for two days and then 100 mg. for one week. She was advised to get water from the city mains supply for making the feeds. The father collected this each evening on his way back from work, and continued to do so. Progress continued as follows:—August 4: no more cyanosis since the introduction of town water; ascorbic acid discontinued; weight 8 lb. 9 oz. (3.9 kg.). September 8: child well; no further cyanosis; weight 10 lb. (4.5 kg.). November 6: child well; weight 11 lb. 14 oz. (5.4 kg.). December 8: satisfactory progress maintained.

On December 8 the child's blood was re-examined for methaemoglobin, which was found to be absent. Since the remainder of the family were still using the well-water and seemed likely to have to continue doing so for some while, the whole family was examined (Table II), although none of them had complained of any ill effects.

Methaemoglobin was determined by the photometric method of Evelyn and Malloy (1938). The method as

TABLE II.—*Methaemoglobin Formation from Nitrates and Nitrites in Water*

Date	Subject	Total Hb % of Normal (Haden) (100% = 15.6 g./100 mL)	Methaemo- globin as % of Total Hb	Drinking- water Supply
4/7/53	Baby (cyanosed)	93	56.8	Well
8/12/53	" (cured)	80	Nil	Town
"	Child (aged 2)	75	16.7	Well
"	" " 3)	70	9.5	"
"	Mother	77	9.5	"
11/12/53	Father	90	Nil	Well-water at night; meals out during the day

described is applicable to the Evelyn-Rubicon photometer, whereas the instrument used here is similar to that described by Salt (1950), fitted with a Tinsley galvanometer. An instrument-correction factor was therefore worked out by means of known solutions of methaemoglobin, and has been applied to the values quoted.

Comment

It can be seen that those members of the family whose water supply was derived entirely from the well all showed levels of methaemoglobin far above the upper limit of the normal range for this method of estimation. The baby, who had been receiving town water for a matter of four months, and the father, who fed out at canteens during the day, both gave negative results.

This short study emphasizes that where a family are relying on a water supply of high nitrate or nitrite content a young baby is more prone to show the effects of methaemoglobinaemia than its elders, as its daily intake of the water, on a weight-for-weight basis, is much larger. Symptoms may be precipitated by the onset of a pyrexial illness, increasing its oxygen demand. Also, if a baby from a rural area presents with a cyanosis unexplained by physical examination, investigations of the water supply may prove to be time well spent.

We are grateful to Mr. M. M. Love, county analyst, for kindly carrying out the water analyses for us.

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Changes in the law governing the production and supply of milk in Scotland come into force on October 1. The changes represent further steps towards securing a safe and clean milk supply. Bottles of pasteurized milk will have to be fitted with caps which seal the lip of the bottle, and bottling will have to be done on the premises where pasteurizing takes place. This is to prevent milk being handled after it has been pasteurized. The special designation "standard" will not be recognized after September 30. In "specified areas," which include all cities and large burghs and many small burghs and landward areas, the sale by retail of standard milk will be forbidden. The only grades of milk allowed to be sold in these areas will be certified, tuberculin tested, pasteurized, and sterilized. A producer's licence to use the special designations certified or tuberculin tested will be granted from October 1 only if the herd from which the milk comes is attested or is in a tuberculosis eradication area of the Ministry of Agriculture and Fisheries. The effect of this is that certified and tuberculin tested milk will in future come from farms where all the cattle, and not only the milk cattle, are certified to be free from bovine tuberculosis.

STAPHYLOCOCCAL FOOD-POISONING DUE TO INFECTED COW'S MILK

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Although *Staph. pyogenes* is commonly found in cow's milk, outbreaks of food-poisoning arising from such a source are relatively very rare. This fact also makes a definite diagnosis difficult, since the isolation of these bacteria from milk or milk products during the investigation of an outbreak of food-poisoning does not imply that they are the cause of it.

This account of two small related outbreaks of food-poisoning is not without interest in that the infective agent, clotted cream, was prepared from milk from a cow that was found to be persistently excreting *Staph. pyogenes* in her milk. Furthermore, the staphylococcus was of a type rarely found in bovine infection, that type being predominantly a human pathogen.

The Outbreaks

On January 9, 1954, notification was received that a small outbreak of food-poisoning had occurred on the previous evening. Seven persons in one family were involved (Table I), and the suspected food was home-made clotted cream. The cream was eaten at 4.30 p.m. and was followed in six cases, in three to three and a half hours, by the abrupt onset of nausea, abdominal pain, and vomiting followed by diarrhoea. In the seventh case symptoms were confined to nausea and general malaise. No case required admission to hospital, but all except the seventh patient were incapacitated for a period varying from six to forty-eight hours.

TABLE I.—*Persons Involved in Outbreak on January 8, 1954*

	Age	Onset	Duration	Nausea	Vomiting	Diarrhoea
Mr. S. ..	67 ?	4 hours	3 hours	+	—	—
Mrs. S. ..	48	3 "	6 "	+	+	+
Mrs. B. ..	45	3-3½ "	48 "	+	+	+
John B. ..	12	3½ "	12 "	+	+	+
Mrs. G. ..	73	3½ "	24 "	+	+	+
Miss H. ..	74	3½ "	24 "	+	+	+
Miss C. ..	66	3½ "	20 "	+	+	+

Further investigations revealed that clotted cream prepared from the milk of the same cow was eaten without ill effect on December 26 but that a similar incident had occurred on January 2 following consumption of the cream by another family living on the same premises (Table II). The cream was prepared on all occasions in a similar manner, on January 2 by Mrs. S. and on January 8 by Mr. S.

TABLE II.—*Persons Involved in Outbreak on January 2, 1954*

	Age	Onset	Duration	Nausea	Vomiting	Diarrhoea
Mr. W. ..	55	3 hours	30 hours	+	+	+
Mrs. W. ..	57	2 "	30 "	+	+	+
Mrs. H. ..	59	3 "	30 "	+	+	+
Mr. A.* ..	21	—	—	—	—	—

* Mr. A. ate only a very small amount of cream, "Less than a teaspoonful."

The cow, a single-house cow, was always milked by Mr. W. It had calved on December 12, 1953, and had not shown any signs of mastitis. Clinical examination revealed the udder to be normal, and the milk from each quarter