The erroneous haemoglobin-hyperlipidaemia relationship

P. D. NICHOLLS

From the Department of Haematology, City Hospital, Hucknall Road, Nottingham NG5 1PB

SUMMARY Hyperlipidaemia, whether primary or secondary to parenteral feeding with intravenous lipid emulsions, causes the haemoglobin level to be erroneously high when measured spectrophotometrically. Contrary to a previous report, evidence is presented which suggests a relationship between the amount of the false rise in the haemoglobin level and the type and degree of hyperlipidaemia.

Nicholls (1973) described an erroneously high reading of the haemoglobin (Hb) level, as measured by the Coulter Model S counter, in patients being fed with intravenous lipid emulsions. Nosanchuk *et al.* (1974) have since reported the case of a diabetic patient in whom a similar error in the measurement of the Hb level was due to a raised triglyceride level. The error occurs because the optical density of the haemoglobin solution is raised by the lipid and this causes falsely high readings of mean cell haemoglobin (MCH) and mean cell haemoglobin concentration (MCHC). The MCHC reading, however, may be falsely low, as sometimes the Coulter counter is unable to do the calculation and produces a result that is exactly half the calculable value (Table). This

paper describes a further case in which the patient showed falsely raised Hb values and incorrect indices of MCH and MCHC. The evidence suggests that the extent of the false rise in the Hb level is related to the type and degree of hyperlipidaemia.

Case report

A 17-year-old white boy was admitted as an emergency with uncontrolled diabetes. He had been diabetic for 15 years and had been treated with protamine zinc insulin, 280 units/day. He had been vomiting for two days before admission. On admission he was drowsy, ketotic, and dehydrated; there were xanthomata on his limbs and milky vessels were seen in the fundi. Diabetic ketosis with hyperlipidaemia was diagnosed. Treatment was by intravenous hydration, insulin, and appropriate diet. Laboratory data on admission are shown in the Table.

The results show that the turbidity due to abnormally high lipid levels caused the Hb value to be erroneously raised by 5.8 g/dl. This was corrected when the Hb level was measured by the washed dilution method of Nicholls (1973). The patient was presumed to be a type V hyperlipidaemia as lipid electrophoresis proved to be technically impossible. During the patient's stay in hospital the triglyceride and cholesterol levels and blood count were monitored regularly. The Hb value was corrected when indicated by MCH and MCHC values outside the normal range, and a definite relationship clearly existed between the triglyceride level and the erroneous rise in Hb level.

The error was calculated by subtracting the washed dilution Hb result from the routine Coulter S result. The relationship was plotted graphically

Table *Results of laboratory investigations on admission of patient with uncontrolled diabetes*

Haematological investigation	Results	
	Neat Coulter S	Washed dilution
Hb (g/dl)*	21.5	15.7
RBC ($\times 10^{12}/l$)	5.36	5.35
PCV (l/l)	0.435	0.436
MCV (fl)	82	82
MCH (pg)	39.2	28.6
MCHC (g/dl)	24.8	35.9
<i>Blood chemistry</i>		
Triglyceride (mg/100 ml)	14200	60-160
Cholesterol (mg/100 ml)	1560	150-250
Sugar (mg/100 ml)	275	65-120
Plasma appearance	Milky white	Clear

*Error in Hb value = 5.8 g/dl

Conversion: traditional units to SI—Triglyceride: 1 mg/100 ml = 0.0113 mmol/l. Cholesterol: 1 mg/100 ml = 0.0259 mmol/l. Glucose: 1 mg/100 ml = 0.0555 mmol/l.

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(Fig. 1). It was shown to have a correlation coefficient $r = +0.98$ and from t-tables this gave a probability value of $P = < 0.001$.

Fig. 1 In-vivo relationship between triglyceride level and error in Hb level.

Conversion: Traditional unit to SI—Triglyceride:
 $1 \text{ mg}/100 \text{ ml} = 0.0113 \text{ mmol/l}$.

IN-VITRO COMPARISON

The findings in the above case lead us to see whether the same relationship held *in vitro* and could be used as a model for the patient and also for patients receiving intravenous lipid emulsions.

Blood was taken from healthy male volunteers into glass universals containing dipotassium EDTA as anticoagulant. To each 10-ml aliquot of blood was added increasing amounts of Intralipid (Paines and Byrne Ltd, Greenford, England) ranging from 0.1 ml to 3.5 ml of a 20% Intralipid solution. Blood counts were made by the routine and the washed dilution methods using the Coulter Model S Counter as previously described. Each of these samples had a triglyceride estimation performed by the department of biochemistry using the method of Lartillot and Vogel (1970). The Hb error and the triglyceride level were plotted graphically (Fig. 2). On statistical analysis of the first part of the graph the correlation coefficient $r = +0.934$ and from t-tables a probability value $P = < 0.001$ was found.

Discussion

Nosanchuk *et al.* (1974) reported several cases in which raised triglyceride levels were associated with erroneously high Hb levels and stated that 'the elevation in Hb and triglyceride do not run in parallel'. Several points arise from that. First, out of the five patients cited none was followed-up serially as in the present case and the data presented represented only isolated measurements. Thus no

Fig. 2 Relationship of error in Hb level and triglyceride level measured *in vitro* ●—●—●. Situation *in vivo* for comparison to show similarity ○—○—○.

relationship could be established for an individual patient. Secondly, the patients had differing types of hyperlipidaemia. Figures 1 and 2 in the present paper show that the slope of the graph in the patient with type V hyperlipidaemia (Fig. 1) differs from that in the Intralipid study (Fig. 2). Thus from Fig. 1 the regression coefficient $m = 0.382$ with a regression equation of $Y = 0.382 X - 0.118$, and from Fig. 2 the regression coefficient $m = 2.713$ with a regression equation of $Y = 2.713 X - 0.237$.

This suggests that each type of hyperlipidaemia exerts its own relationship on the amount of rise in the Hb value, depending on the chylomicron and other lipid particle content. Thus types I, III, IV, and V, as classified by electrophoresis, could each be expected to show its own peculiar relationship with the error in the measurement of Hb level it produced, since each type will result in a milky or turbid plasma. We found from the graphs that, by noting the error in Hb value, we could predict with reasonable accuracy the triglyceride level. Nevertheless, this should in no way be used in clinical practice to replace the biochemical estimation of the triglyceride level. The washed dilution method relies for its quality control on the red cell count being the same before washing (that is, routine processing) and after washing (Nicholls, 1973). This requires considerable

attention to technical detail but at least allows some control over the method. As more patients present with varying types of hyperlipidaemia and are followed in a serial manner for triglyceride and Hb estimations we may hope that the exact nature of the relationship between triglyceride level, error in Hb measurement, and type of hyperlipidaemia will be established.

Since the original draft of this paper was written we have seen a patient who was given Intralipid intravenously after an operation. Triglyceride and Hb levels were measured on three occasions. The results are shown in Fig. 2. As these show exactly the same pattern as the *in-vitro* Intralipid study this has further strengthened the belief that a relationship exists between the triglyceride level and the error in the measurement of the Hb level.

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