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enzymatic assay for ethylene glycol, however, has not been previously documented. The interference may not have been appreciated in previous evaluations of the assay because test compounds, such as lactate and alcohols, were added to normal serum, not sera from critically ill patients [2]. To evaluate the performance of the enzymatic assays for ethylene glycol and ethanol in hospitalized patients with abnormal serum chemistry, we added α1-lactic acid to two random serum samples with markedly increased LD and performed the enzymatic assays (Table 1). Lactate per se does not interfere in the assay; however, the concomitant presence of LD under the proper assay conditions produces NADH, resulting in substantial false-positive values in the enzymatic assays for ethylene glycol and ethanol. Given their correlation with the concentrations of LD and lactic acid, these false-positive values may be due to the LD-catalyzed conversion of serum lactate and reagent NAD+ to pyruvate and NADH.

To support this hypothesis, we reconstituted normal serum with increasing concentrations of LD-5 purified from human placenta (Sigma Chemical Co., St. Louis, MO) in the presence of 0, 10, or 50 mmol/L α1-lactic acid (Sigma). The ethylene glycol enzymatic assay gave falsely positive results when LD serum activity was >3000 U/L, as did the ethanol enzymatic assay when LD serum activity was >2000 U/L (Fig. 1). The interference was most pronounced when the concentration of α1-lactate exceeded 10 mmol/L. These data, however, should not be strictly extrapolated to the clinical setting because the contribution to total LD activity in this experiment was due solely to LD-5, and the concentration of lactate consisted of approximately equal amounts of L- and D-isomers. In hospitalized patients, increased LD activity may be due primarily to the contribution of a different isoenzyme or of more than one isoenzyme, and increased lactate concentration will most probably be the L-isomer. However, the data obtained from three hospitalized patients with increased serum LD activity (Table 1) support a clinically relevant guideline that significant false-positive results occur when the LD serum activity is at least 12-fold greater than the upper limit of the reference interval, and lactate is concomitantly at least 10-fold greater than the upper limit of its reference interval.

High concentrations of lactate and LD in sera from critically ill patients interfered in the enzymatic assay for ethylene glycol by increasing the production of NADH. Although lactate added to normal sera does not interfere with the assay, results should be interpreted cautiously in samples with high LD and lactate concentrations. Other interferences reported for the ethylene glycol enzymatic assay include glyceraldehyde and glycerol, which can be oxidized by the enzyme glycerol dehydrogenase [2]. The enzymatic assay is otherwise very specific, and other alcohols—including ethanol, methanol, and isopropanol—do not interfere with interpretation. Ethylene glycol poisoning of previously healthy individuals may result in lactic acidosis but will not typically result in increased LD. However, this analytical interference becomes clinically relevant in cases of suspected ethylene glycol poisoning of individuals with hepatic, renal, or cardiac disease who may manifest both lactic acidosis and increased serum LD. Positive results in the enzymatic assay for ethylene glycol in such cases should be confirmed with a different method such as gas chromatography.

We thank Brian Gilmore for expert technical assistance.

References


According to the recommendations of the National Cholesterol Education Program Adult Treatment Panel, low-density lipoprotein cholesterol (LDL-cholesterol) should be used for screening and as a primary treatment criterion for patients with increased total cholesterol concentrations [1]. This makes the need for accurate measurements of LDL-cholesterol a national public health imperative. The use of the Friedewald equation is attractive, but its accuracy is in doubt in plasma samples with triglyceride (TG) concentrations >4.5 mmol/L (400 mg/dL) [2–7]. A decennium ago we found the Friedewald equation to be accurate up to a TG concentration of 8 mmol/L [8]. Assuming that similar plasma samples were analyzed, these findings raise questions about the quality of the methods used in other laboratories, especially in the analysis of hypertriglyceridemic samples. The disposal of a direct LDL-cholesterol method not interfered with by hypertriglyceridemia [9] prompted us to evaluate its accuracy in hyperlipidemic samples, including a selection with familial dysbetalipoproteinemia (FD). We hoped that this reevaluation could shed more light on our previously reported claim concerning the accuracy of the Friedewald calculation compared with that of the reference method [8].

Overnight fasted blood samples from healthy persons and from patients with various types of hyperlipoproteinemia were drawn into Vacutainer Tubes containing EDTA (Becton Dickinson, Meylan Cedex, France). Plasma samples were analyzed fresh. If sufficient amounts of plasma were available, two aliquots were stored at −80°C for >3 months; one was supplied with saccharose (final concentration 6 g/L). Patients were classified into the different phenotypes according to the criteria of Fredrickson et al. [10] with cutoff limits for plasma cholesterol, TG, and LDL-cholesterol of 6.5, 2.0, and 4.6 mmol/L, respectively. Plasma samples with lipemia, especially those from subjects with FD, were preferentially included. This means that the frequency of samples with FD was considerably higher than in the healthy population. The 217 fresh plasma samples analyzed included, by selection, 63 with a plasma TG >8.0 mmol/L; 11 had a VLDL-cholesterol/plasma TG ratio >0.69.
(diagnostic for FD [11]). The latter subjects were homozygotes for apoprotein E2 [12]. Following the strategy of our preceding study [9], we classified plasma of subjects with fasting plasma TG concentrations <8 mmol/L as phenotype IV and those >8 mmol/L as phenotype V hyperlipoproteinemia.

Besides the 217 samples analyzed fresh with the ultracentrifugation method and the Friedewald formula, 147 fresh samples were also available for analysis with the immunopreparation method; 110 of these samples could be analyzed both fresh and after freeze-thawing, including 64 to which saccharose (final concentration 6 g/L) was added before freezing.

The reference method we used was a combined ultracentrifugation/preservation procedure. VLDL-chol was determined directly in the VLDL isolated by sequential ultracentrifugation [13]. After ultracentrifugation of plasma in the TFT 45.6 rotor (Kontron, Zürich, Switzerland) for 16 h at 131,000 rpm in the Beckman L7-55 ultracentrifuge at 4°C, the density <1.006 kg/L fraction was aspirated by means of a rubber bulb Pasteur pipette. HLDL-chol was determined in plasma after precipitation of the VLDL and LDL with phosphotungstic acid and MgCl2 (cat. no. 543004; Boehringer Mannheim, Mannheim, Germany). LDL-chol was calculated by subtraction. Reproducibility, expressed as the CV, was 4.3% for VLDL-chol determination, 2.6% for HLDL-chol determination, and 2.3% for LDL-chol calculation (n = 30).

The LDL-immunopreparation reagent was obtained from Sigma (Sigma LDL-cholesterol, cat. no. 555-A, lot no. 05516275; St. Louis, MO). The procedure was performed according to the manufacturer’s directions. The LDL-chol reagent consists of a suspension of polystyrene latex beads coated with goat polyclonal antibodies to human apoproteins in a buffer containing 1 g/L sodium azide. From this reagent 200 μL is pipetted into the inner compartment of a separation tube (fitted microcentrifugation tubes); to the same compartment we added 30 μL of either the controls (concentrations low and high, included in the kit) or plasma, capped the tubes, and vortex-mixed them. After incubation for 5 to 10 min at room temperature, we centrifuged the tubes for 10 min at 4300 g at room temperature. Subsequently, the filtrate in the outer compartment was vortex-mixed and assayed for cholesterol. Although the vortex-mixing step was not mentioned in the procedure, the accuracy of the Friedewald equation correlated very well with the reference method, similarly as those obtained with the LDL-direct method (n = 115) (correlation coefficients 0.99 vs 0.85, S1/2 values 0.34 vs 0.55, respectively). However, after exclusion of the samples with plasma TG >8.0 mmol/L and the samples of the patients with FD (all having a VLDL-chol/plasma TG ratio >0.69), the results (n = 177) obtained with the Friedewald equation correlated well with the reference method, similarly as those obtained with the LDL-direct method (n = 115) (correlation coefficients >0.97, S1/2 values <0.21, regression equations by Passing and Bablock analysis not different from the identity curve y = x). These results are in agreement with the non-FD samples with TG concentrations between 4 and 8 mmol/L, which were similar to the general mean results (data not shown). These findings can be explained by the relative constancy of the ratio VLDL-chol/plasma TG in the plasma samples with TG concentrations up to 14 mmol/L (Fig. 1). Thus, we did not obtain evidence for a shift in the chemical composition data as a result of an excess of chylo-microns at increasing plasma TG values.

In the non-FD samples with TG <8.0 mmol/L, the direct LDL-ultracentrifugation comparison and the direct LDL-ultracentrifugation comparison were similar (S1/2 values 0.17 vs 0.21, respectively).

A negative bias of ~11% was obtained with the direct method (y) after prior storage of the plasma samples at −80°C compared with the reference method (x): mean x, 4.12 ± 1.98 mmol/L; mean y, 3.58 ± 1.75 mmol/L; linear regression equation y = 0.88x − 0.02, correlation coefficient r = 0.93, S1/2 = 0.35, n = 110. Apparently, some of the LDL was retained in the column. Addition of 6 g of saccharose per liter of plasma before freezing prevented this, as could be derived from the statistical results: mean x, 4.01 ± 1.98 mmol/L; mean y, 3.81 ± 1.80 mmol/L. The accuracy of the procedure was checked against the improved Abell–Kendall procedure and the bias was <0.3%; imprecision was 1.9% (n = 30). TG were analyzed on the Hitachi 747; the accuracy was checked against a semiautomated colorimetric method [13]; imprecision was 1.6% (n = 30) for concentrations up to 12 mmol/L. The accuracy of the HDL-chol method was confirmed by comparison with sequential ultracentrifugation and against the polyethylene glycol-6000 precipitation method [16, 17] and unpublished observations. The HDL-method used appeared to be very convenient for normo- and hyperlipidemic plasma in that very few samples had to be ultrafiltered to clear turbid supernates.

Results were analyzed by Student’s paired t-test. Results obtained by different methods were correlated by using Pearson’s correlation test with the application of the SPSS/PC statistical software (version 3.1) (SPSS, Chicago, IL).
the drawing of conclusions concerning the optimal estimation hypertriglyceridemic plasma samples are analyzed. This is sup­
tations >4.00 g/L (4.5 mmol/L), large standard deviations prevent
we observed, independent of die plasma TG concentration. Our
Friedewald formula is biased or imprecise, especially when
analytical mediods delivering values for substitution in die
ported by die relatively constant estimate for VLDL-chol that
that die analysis of fasting plasma samples in our study merely
die reference value did not differ from 1.0 (Passing and Bablock
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ments in general and the accuracy of our reference method
thought to result in too low LDL-chol values because VLDL-
tion in our hands could be due to the fact that we analyzed fasted
plasma samples with TG >8.0 mmol/L.

4.5 and 8 mmol/L, at least when the seldom-occurring samples
accurate in plasma samples with TG concentrations <4.5
excluded. With the latter samples a positive bias is obtained
that expresses the additional coronary heart disease risk due to the
contribution of VLDL remnants.

Up to a TG concentration of 8 mmol/L the Friedewald approach
and the direct LDL method gave similar scores both for
accuracy and precision, stressing the validity of our experi­
ments in general and the accuracy of our reference method
especially. The greater applicability of the Friedewald calcula­
tion in our hands be due to the fact that we analyzed fasted
plasma samples. Chylomicrons present in nonfasting plasma are
thought to result in too low LDL-chol values because VLDL-
chol in these samples is overestimated when using 0.45 × plasma
TG (in mmol/L) as an approach. However, even in the non-FD
samples with a plasma TG concentration of 8 to 14 mmol/L,
characterized by increased concentrations of chylomicrons, sta­
tistical analysis revealed that the intercept of the curve depicting
the relation between the estimated and determined LDL-chol vs
the reference value did not differ from 1.0 (Passing and Bablock
analysis, data not shown). This cast doubts on the suggestion
that the analysis of fasting plasma samples in our study merely
explains the difference in the applicability of the Friedewald
formula compared with other laboratories. This is also sup­
ported by the relatively constant estimate for VLDL-chol that
we observed, independent of the plasma TG concentration. Our
observations suggest that in other laboratories one of the
analytical methods delivering values for substitution in the
Friedewald formula is biased or imprecise, especially when
hypertriglyceridemic plasma samples are analyzed. This is sup­
ported by the results of McNama r et al. [2]: At TG concentra­
tions >4.00 g/L (4.5 mmol/L), large standard deviations prevent
the drawing of conclusions concerning the optimal estimation

1.87 mmol/L, \( P = 0.12 \); linear regression equation \( y = 0.99x - 0.01 \), \( r = 0.92 \), \( S_{\text{exp}} = 0.22 \), \( n = 64 \).

In the present study we confirm our earlier findings \[8\] that
estimated LDL-chol by the Friedewald formula is not only
accurate in plasma samples with TG concentrations <4.5
mmol/L, but also in samples with TG concentrations between
4.5 and 8 mmol/L, at least when the seldom-occurring samples
with FD (prevalence –0.1–0.5% in the healthy population) are
excluded. With the latter samples a positive bias is obtained \[8\]
which expresses the additional coronary heart disease risk due to the
contribution of VLDL remnants.

We thank Sigma Diagnostics for providing the reagents of the
immunoseparation kit.

References

1. Report of the National Cholesterol Education Program Expert Panel on
detection, evaluation and treatment of high blood cholesterol in adults. Arch
2. McNamara JR, Cohn JS, Wilson PWF, Schaefer EJ. Calculated values for
low-density lipoprotein cholesterol in the assessment of lipid abnormalities
3. Rifai N, Warnick GR, McNamara JR, Belcher JD, Grinstead GF, Franz ID Jr.
Measurement of low-density lipoprotein cholesterol in serum: a status
4. Manninen J, Mäki J, Mästås J, Jämsä J, Imposa O. Poor applicability of
the Friedewald formula in the assessment of serum LDL cholesterol for
5. Jialal I, Hirany SV, Devaraj S, Sherwood TA. Comparison of an
immunoprecipitation method for direct measurement of LDL-cholesterol
the Friedewald formula for estimating low-density lipoprotein cholesterol
A characteristic rise and fall in the concentrations of creatine kinase (CK) and its MB isoenzyme are often used as indicators of myocardial damage [1]. However, CK may be abnormally high in up to 90% of patients with hypothyroidism [2]. This increase is mostly from increased MM, but MB has also been reported to increase above reference values in hypothyroid patients without apparent myocardial damage [3]. Hypothyroid patients experience skeletal muscle signs and symptoms, including muscle cramps, stiffness, myalgias, and myoclonus [4]. However, even some without muscle complaints have increased CK, probably because of decreased clearance of CK and CK-MB [3].

Coronary atherosclerosis occurs twice as frequently in patients with hypothyroidism as in age- and sex-matched controls [5]. Because of their increased tendency to develop hypertension and hypercholesterolemia, hypothyroid patients are predisposed to coronary artery disease and subsequently to myocardial infarction. Saito et al. found that hypertension was more frequent in hypothyroid patients than in age-matched euthyroid persons [6]. Also, cholesterol-fed animals with hypothyroidism develop accelerated atherosclerosis that is reduced after thyroid hormone replacement [7]. These observations suggest that the concomitant occurrence of ischemic heart disease and hypothyroidism will be a recurring concern.

Recently, the new markers troponin T and troponin I (Tn-I) have been extensively studied because of their cardiac specificity. Their concentrations increase within 6 h of myocardial injury and remain increased for as long as 7 days. However, increased concentrations of troponin T have also been found in polymyositis/dermatomyositis [8], renal failure [9], trauma [10], and rhabdomyolysis [10], whereas no increase in Tn-I is seen in patients with rhabdomyolysis, multiple trauma, chronic muscle disease, chronic renal failure, or in marathon runners [11-15]. Given the apparent lack of published reports on Tn-I values in hypothyroidism and in view of the difficulty in interpreting CK and CK-MB, we studied the effect of hypothyroidism on Tn-I.

A case that illustrated the above points and was the impetus for this study was that of a 55-year-old white man who presented to the hospital with the complaint of intermittent left-side chest pain and progressive shortness of breath and edema for 6 months. He had a history of an anterosetal myocardial infarction in 1982 and complained of constipation and weight gain. Chest x-ray revealed cardiomegaly and congestive failure, and echocardiogram showed a pericardial effusion. Laboratory values were as follows: CK 9160 U/L (reference range 50-150 U/L), Troponin T 2.8 μg/L (reference range <0.1 μg/L), and cardiac Tn-I <0.4 μg/L. On the basis of these findings, he was ruled out for acute myocardial infarction.

Recently, we reviewed 52 consecutive patients presenting to Parkland Memorial Hospital in late January and early February 1996 in whom a thyrnotropin (TSH) value >25 mU/L was observed (reference range 0.4-4.5 mU/L). The procedures we followed were within the standards set by the Ethics Committee of our institution. Because this was a laboratory-initiated study, we cannot report on the severity of the hypothyroidism based on clinical findings, and the findings in this study should be interpreted in that light. Most of these patients were seen in the outpatient clinic for management of their hypothyroid state. Various etiologies of hypothyroidism were observed. Two patients had atypical chest pain, but infarction was excluded. Ages ranged from 26 to 70 years (mean 46), an age group not uncommonly encountered in the evaluation of ischemic heart disease. The patients studied were 42 women and 10 men. TSH values ranged from 25.1 to 295.5 mU/L (mean 79.7). Free thyroxine (FT4) values ranged from undetectable to 12.9 pmol/L (reference range 10.3-23.2 pmol/L). The same sample used to measure TSH and FT4 was also used to measure CK, CK-MB, cholesterol, and cardiac Tn-I. TSH and FT4 were measured on the Ciba Corning (Medfield, MA) ACS:180® with an immuno-