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Hypertriglyceridemia and its impact on hematological indicators: A study based on Turkish national health database

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ABSTRACT

OBJECTIVE: The hematocrit (Hct) to hemoglobin (Hb) ratio, generally at 3.0 in healthy individuals, can vary in certain disease states. An emerging area of interest is the potential influence of triglyceride concentrations on this ratio and hemoglobin A1C (HbA1c) levels. This study aimed to identify the changes in HbA1c and the Hct/Hb ratio as triglyceride concentration increases.

METHODS: This research involved an extensive analysis of 35,656,613 laboratory samples taken between January 2015 and December 2022 in Türkiye, including the respective triglyceride, Hb, Hct, and HbA1c results. The laboratory test results were obtained from the national health database of the Turkish Ministry of Health. The triglyceride levels were divided into 24 groups, each incremented by 100 mg/dL from a range of 0–3099 mg/dL. Mean and standard deviation values of Hb and Hct were calculated for each group, and the Hct/Hb ratio was graphically represented.

RESULTS: The average HbA1c values ranged between 4.37±0.85 and 7.76±3.19 across the groups, Hb averages ranged from 9.75±1.7 to 14.03±2.21, Hct averages from 27.35±4.97 to 38.86±5.66, and Hct/Hb ratios varied between 2.77 and 3.03. The overall average for all samples was identified as 5.15±0.13 for HbA1c, 38.48±5.13 for Hct, 12.73±1.65 for Hb, and 3.02 for the Hct/Hb ratio.

CONCLUSION: It was observed that the Hct/Hb ratio gradually decreased as triglyceride levels increased. Evaluating anemia based on Hb concentration in individuals with hypertriglyceridemia might be misleading. It is recommended to use a correction factor based on triglyceride level.

Keywords: Big data; health management; hematocrit; hemoglobin; hypertriglyceridemia.

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Hypertriglyceridemia is a condition that arises after satiety as a result of a biological process. However, in pathological states, certain primary and secondary factors trigger this condition. Factors causing primary elevation are usually of genetic origin. These include familial hypertriglyceridemia, familial lipoprotein lipase deficiency, familial apolipoprotein CII deficiency, hepatic lipase deficiency, familial combined hyperlipidemia, and dysbetalipoproteinemia. On the other hand, various systemic conditions such as diabetes mellitus, hypothyroidism, renal diseases, liver diseases, and alcoholism are among the factors triggering secondary elevation [1].

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Hypertriglyceridemia has a series of significant effects both within (*in vivo*) and outside (*in vitro*) a living organism. In the *in vivo* environment, this condition particularly triggers visceral fat accumulation and cardiovascular system diseases, while in the *in vitro* environment, it creates significant interference in the measurement of biochemical tests. It is known that enzymes (Alanine transaminase, aspartate transaminase, creatine kinase, creatine kinase-MB, and lactate dehydrogenase) and electrolytes (Sodium (Na), Potassium (K), chloride (Cl), and Calcium (Ca)) are affected due to lipemia [2].

However, in a particular study, it was shown that the negative interference created by high triglycerides in 25-hydroxy Vitamin D (25OHD) vitamin led to unnecessary Vitamin D loading and eventually to intoxication [3, 4]. Furthermore, in another case, it was found that congenital hypertriglyceridemia caused an erroneous high measurement of hemoglobin (Hb) levels [5].

In this context, hypertriglyceridemia can affect complete blood count tests, and this effect may vary depending on triglyceride levels. The aim of this study is to examine the effect of various triglyceride levels in Türkiye on Hb, hematocrit (Hct), hemoglobin A1C (HbA1c) levels, and the Hct/Hb ratio. This analysis aims to assist in the more accurate assessment of diseases and the prevention of complications due to hypertriglyceridemia. This research will both provide a general overview of hypertriglyceridemia and increase our understanding of the impact of this condition on biochemical tests and the overall health of patients.

Highlight key points

- This research includes a comprehensive analysis of 35,656,613 laboratory samples taken between 2015 and 2022 in Türkiye.
- Triglyceride levels influence the ratio between hemoglobin and hematocrit values.
- A more sensitive and careful approach should be adopted in the evaluation and treatment of patients with high lipid levels.

MATERIALS AND METHODS

This study includes triglyceride, Hb, Hct, and HbA1c results synchronized in laboratories in Türkiye between January 2015 and December 2022. Laboratory test results were obtained through the National Health Data Base of the Ministry of Health of Türkiye. The National Health Data Base includes laboratory service information and test process information for laboratory tests. Test process information includes the test name, test result, test unit, and reference range, while laboratory service information includes individuals' demographic information. Hemogram tests in Türkiye are generally performed using impedance and laser scatter methods. The HbA1c test is performed turbidimetrically and chromatographically. Method differences cannot be distinguished from the data transferred to the database. The triglyceride test is obtained using various biochemical autoanalyzers, and test results are transferred to the database after being confirmed in the laboratory. For this study, 35,656,613 samples were evaluated. Serum samples taken for triglycerides and whole blood samples taken for hemogram have the same process number and are synchronized. Samples below seven and above 18 for Hb, below 21 and above 54 for Hct were excluded from the study. Synchronized Hb, Hct, HbA1c, and triglyceride tests from 35,639,848 samples were included in the study. The data of the group between 1400–1599, 1700–1899, 2200–2299, and 2600–2699 were excluded as they affected linearity. The total number of excluded samples is 16.765. The eliminated data are 0.04% of the total data. According to triglyceride concentrations, 24 different groups were formed as 0–99, 100–199, 200–299, 300–399, 400–499, 500–599, 600–699, 700–799, 800–899, 900–999, 1000–1099, 1100–1199, 1200–1299, 1300–1399, 1400–1499, 1500–1599, 1600–1699, 1700–1799, 1800–1899, 1900–1999, 2000–2099, 2100–2199, 2200–2299, 2300–2399, 2400–2499, 2500–2599, 2600–2699, 2700–2799, 2800–2899, 2900–2999, and 3000–3099 mg/dL. Mean±SD values of Hb, Hct, and HbA1c were calculated for each group. The Hct/Hb ratio of Group 1 was taken as the target value, and the deviation percentage of the Hct/Hb ratios in other groups was calculated.

This study was conducted in accordance with the Helsinki Declaration. The Institutional Review Board approval was obtained, and all data were anonymized to ensure privacy. Approval was obtained from the Ministry of Health of Türkiye with an informed consent waiver for retrospective data analysis (95741342-020/27112019).

Statistical Analysis

The study data were transferred to the IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY) program,

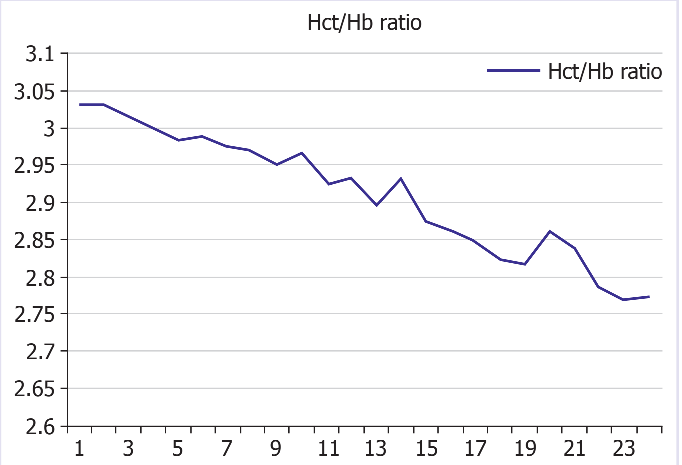

Figure 1. Hct/Hb ratio change through increasing triglyceride concentration.

Hct: Hematocrit; Hb: Hemoglobin;

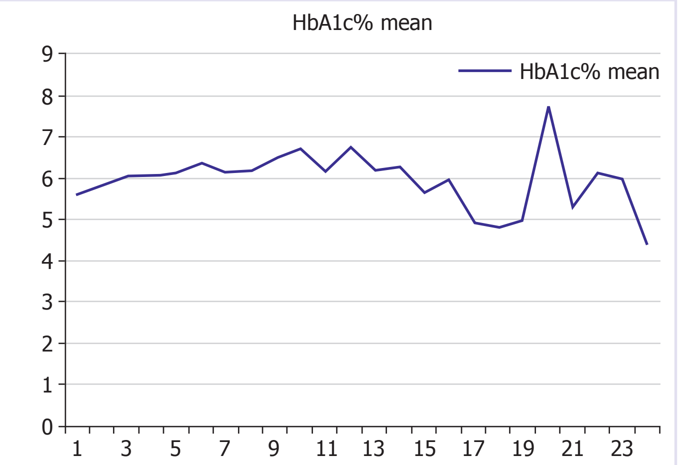

Figure 2. HbA1c% change through increasing triglyceride concentration.

and the analyses were completed. Descriptive statistics (mean, standard deviation) were given for numerical data. The mean and SD values of Hb and Hct values for each group were calculated, and the Hct/Hb ratio was graphically expressed (Figs. 1, 2).

RESULTS

Data obtained from 35,656,613 patient samples were included in the study, and Hb, Hct, Hct/Hb ratio, and triglyceride results were used simultaneously. While calculating the averages of HbA1c, Hb, Hct, and Hct/Hb, 24 groups were formed with triglyceride levels increasing by 100 mg/dL between 0 and 3099 mg/dL (Table 1). The average HbA1c in the groups varies between 4.37±0.85 and 7.76±3.19, the average Hb varies between 9.75±1.7 and 14.03±2.21, the average Hct varies between 27.35±4.97 and 38.86±5.66, and the Hct/Hb ratio varies between 2.77 and 3.03. The average HbA1c of all samples was determined as 5.15±0.13, the average Hct as 38.48±5.13, the average Hb as 12.73±1.65, and the average Hct/Hb as 3.02. The maximum change in the Hct/Hb ratio was calculated as −9.39%.

DISCUSSION

This study emphasizes the importance of careful and accurate analytical practices in clinical laboratory applications, particularly by examining the potential effects of high triglyceride concentrations on Hb and Hct values.

Biochemical measurements in blood samples of individuals with hypertriglyceridemia often encounter interference, and this can complicate both diagnosis and treatment. High triglyceride concentrations can lead to erroneous results in Hb measurements, while they do not affect Hct values [5, 6]. Therefore, the ratio between Hct and Hb values usually decreases. In addition, it has been noted that there could be misleading results in the measurement of pancreatic enzymes, especially in cases of hypertriglyceridemia [7, 8].

The ratio of Hct to Hb has long been accepted as 2.941 [9]. This ratio has been simplified to three in daily clinical practice. This figure is applicable to people with normal red blood cell morphology. In different thalassemia genotypes, Hct/Hb ratios are determined above 3.0. In studies on the Hb H disease genotype, the Hct/Hb ratio was measured as 3.6 by Kanavakis et al., 3.8 by Todd et al. and 3.4 by Qadri et al. [10–12]. In our study conducted across Türkiye, 25OHD vitamin levels were shown to change depending on triglyceride concentration [4].

The results of this study provide significant illumination in clinical practices and laboratory analyses. Specifically, it has been observed that in patients with high triglyceride concentrations, the Hct/Hb ratio could be low, and Hb could potentially be measured erroneously high. This situation requires a more careful approach, especially in individuals with high lipid levels.

These results provide additional guidance to clinicians and laboratory technicians when evaluating the test results of patients with high triglyceride levels

Table 1. HbA1c, Hb, Hct, and Hct/Hb ratio changes according to triglyceride concentrations

	Triglyceride (mg/dL)	HbA1c (%)	Hematocrit (mean±SD)	Hb (mean±SD)	Hct/Hb ratio	Deviation percentage*	Number of samples
Group 1	0–99	5.6±0.84	36.62±6.48	12.08±2.27	3.03	0	13042552
Group 2	100–199	5.82±1.0	36.51±7.09	12.05±2.46	3.03	0	16118889
Group 3	200–299	6.02±1.27	36.32±7.65	12.05±2.65	3.01	–0.66	4256951
Group 4	300–399	6.05±1.25	35.81±7.96	11.94±2.75	3.00	–1	1268102
Group 5	400–499	6.13±1.48	35.06±8.33	11.75±2.84	2.98	–1.68	466808
Group 6	500–599	6.34±1.67	35.44±8.58	11.86±2.91	2.99	–1.34	203657
Group 7	600–699	6.14±1.51	33.67±8.16	11.32±2.81	2.97	–2.02	99542
Group 8	700–799	6.2±1.45	32.92±7.6	11.09±2.62	2.97	–2.02	72083
Group 9	800–899	6.49±1.5	33.45±8.3	11.33±2.87	2.95	–2.71	28763
Group 10	900–999	6.72±1.8	36.46±8	12.29±2.89	2.97	–2.02	12584
Group 11	1000–1099	6.15±1.62	31.64±7.83	10.82±2.69	2.92	–3.77	20188
Group 12	1100–1199	6.75±1.59	30.85±7.72	10.52±2.73	2.93	–3.41	14303
Group 13	1200–1299	6.18±1.11	31.92±7.23	11.02±2.62	2.90	–4.48	14809
Group 14	1300–1399	6.26±2.07	38±7.28	12.97±2.53	2.93	–3.41	4815
Group 15	1600–1699	5.64±1.93	30.84±6.58	10.73±2.31	2.87	–5.57	5193
Group 16	1900–1999	5.95±1.37	38.16±5.87	13.33±2.29	2.86	–5.94	780
Group 17	2000–2099	4.9±1.31	30±6.72	10.54±2.23	2.85	–6.32	2021
Group 18	2100–2199	4.81±1.38	30.54±7.51	10.82±2.42	2.82	–7.45	1747
Group 19	2300–2399	4.96±1.75	30.53±7.2	10.84±2.35	2.82	–7.45	1835
Group 20	2400–2499	7.76±3.19	38.3±6.46	13.39±2.37	2.86	–5.94	382
Group 21	2500–2599	5.29±1.42	27.67±4.62	9.75±1.7	2.84	–6.69	2105
Group 22	2700–2799	6.13±1.45	36.1±7.96	12.96±2.46	2.79	–8.6	267
Group 23	2900–2999	5.97±1.25	38.86±5.66	14.03±2.21	2.77	–9.39	136
Group 24	3000–3099	4.37±0.85	27.35±4.97	9.86±1.73	2.77	–9.39	1336
All groups	0–3099	5.15±0.13	38.48±5.13	12.73±1.65	3.02		35639848

*: Deviation percentage of Hct/Hb ratio in other groups by taking group1's Hct/Hb ratio as target value. Hb: Hemoglobin; Hct: Hematocrit; SD: Standard deviation.

and determining the relevant treatment approaches. As in this study, big data analysis; proper use of tests can be very helpful in detecting potential test interactions. It is thought that big data analyses will become more and more important in the development of efficiency, cost, and treatment approaches in terms of health management.

However, there are some limitations to the study. First, the study is based on retrospective data, which can make it difficult to determine causative relationships. Second, the diversity of laboratory measurement methods can complicate the interpretation of results. As mentioned in the study, there are some differences between the methods used for hemogram (CBC) and triglyceride tests, and these differences can lead to slight variations in results. Third, the fact that the study sample is limited to patients in Türkiye restricts the generalizability of the results to other populations.

Finally, since this study focused on the effect of triglyceride levels on Hb and Hct, other potential influencers have been overlooked. For example, it is known that factors such as patients' dietary habits, lifestyle factors, or genetic variations could affect Hb and Hct values and the ratio between them. Taking such factors into account could broaden the scope of future studies.

Conclusion

This study has demonstrated that triglyceride levels have an impact on the ratio between Hb and Hct values. Despite advancements in modern measurement techniques, lipemia continues to be one of the main causes of analytical errors. This poses a significant challenge for clinical practices and patient evaluations. Therefore, the use of reference measurement methods could be an effective solution in minimizing such errors and obtaining more reliable and accurate results. In addition, deriving the Hb values of patients with high triglyceride levels from Hct values could be a more accurate approach in such situations. Hence, the necessity of adopting a more sensitive and careful approach in the evaluation and treatment of patients with high lipid levels is emphasized once again. It could also offer practical suggestions and strategies for improving the use and evaluation of tumor markers in healthcare delivery.

Ethics Committee Approval: Approval was obtained from the Ministry of Health of Türkiye with an informed consent waiver for retrospective data analysis (date: 27.11.2019, number: 95741342-020).

Conflict of Interest: No conflict of interest was declared by the authors.

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Authorship Contributions: Concept – SB, MMU, MC; Design – SB, NA, MC; Supervision – SB, MMU, NA, MC; Data collection and/or processing – SB, MMU, NA; Analysis and/or interpretation – MMU, NA; Literature review – SB, MMU, NA, MC; Writing – SB, MMU, NA, MC; Critical review – SB, MMU, NA, MC.

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