**Name of Journal:** *World Journal of Clinical Cases*

**Manuscript NO:** 56640

**Manuscript Type:** CASE REPORT

**Severe hyperlipemia-induced pseudoerythrocytosis - Implication for misdiagnosis and blood transfusion: A case report and literature review**

Zhao X C *et al*. Hyperlipemia-induced pseudoerythrocytosis

Xi-Chen Zhao, Bo Ju, Na Wei, Jian Ding, Fan-Jun Meng, Hong-Guo Zhao

**Xi-Chen Zhao, Bo Ju, Na Wei,** Department of Hematology, The Central Hospital of Qingdao West Coast New Area, Qingdao 266555, Shandong Province, China

**Jian Ding,** Department of Clinical laboratory, The Central Hospital of Qingdao West Coast New Area, Qingdao 266555, Shandong Province, China

**Fan-Jun Meng, Hong-Guo Zhao,** Department of Hematology, The Affiliated Hospital of Qingdao University, Qingdao 266000, Shandong Province, China

**Author contributions:** Zhao XC designed the study and drafted the manuscript; Zhao XC, Ju B, and Wei N participated in the treatment of this patient; Ding J performed the laboratory tests; Meng FJ and Zhao HG supervised the treatment and revised the manuscript.

**Corresponding author: Hong-Guo Zhao, MD, Chief Doctor, Professor,** Department of Hematology, The Affiliated Hospital of Qingdao University, No. 16 Jiangsu Road, Qingdao 266000, Shandong Province, China. zhaohongguo6201@163.com

**Received:** May 8, 2020

**Revised:** July 30, 2020

**Accepted:** August 29, 2020

**Published online:**

**Abstract**

BACKGROUND

Severe hyperlipemia (SHLE) has an impact on the results of many kinds of laboratory tests. Complete blood count (CBC) examination by automated blood cell counter (ABCC) is a quick and convenient measurement for screening abnormalities of blood cells that are triggered by various pathogenic insults in disease diagnosis and for monitoring changes in the treatment of existing hematological conditions. However, CBC results are frequently affected by many intrinsic and extrinsic factors from blood samples, such as in the setting of hypergammaglobulinemia and certain anticoagulants. SHLE could also affect CBC results.

CASE SUMMARY

A 33-year-old Chinese male presented with painful foot numbness and abdominal pain. He was initially misdiagnosed as having a myeloproliferative neoplasm (MPN) because of the marked abnormalities in CBC examination by the ABCC. Morphological evaluation of the bone marrow smears and biopsy showed no evidence of MPN. Gene mutations in *B-cell receptor-Abelson murine leukemia viral oncogene homologue 1*, *Janus kinase*, *calreticulin,* *myeloproliferative leukemia virus*, and *colony-stimulating factor 3 receptor* were negative. Having noticed the thick chylomicron layer on blood samples and the dramatically fluctuating CBC results, we speculated that the fat droplets formed by shaking the blood samples in the setting of SHLE were mistakenly identified as blood cells due to the limited parameters of ABCC. Therefore, we removed a large part of the chylomicron layer and then reexamined the CBC, and the CBC results, as we expected, differed significantly from that of the sample before the chylomicron layer was removed. These significant differences had been validated by the subsequently repeated laboratory tests by measuring dual blood samples that the chylomicron layer was removed in one sample and was not in another, and comparing the CBC results. Computerized tomography reexamination of the upper abdomen revealed an exudative lesion surrounding his pancreas. After intensive consultation, definitive diagnosis was made as recurrent pancreatitis, hyperlipemia and pseudoerythrocytosis.

CONCLUSION

SHLE may become a potential cause of misdiagnosis of hyperlipemia-related diseases as MPNs and the resultant mistreatment. It may also lead to the misinterpretation of transfusion indications in patients with hematological disorders who critically need blood transfusion for supportive treatment.

**Key words:** Case report; Hyperlipemia; Fat droplet; Pancreatitis; Pseudoerythrocytosis; Blood transfusion indication

Zhao X-C, Ju B, Wei N, Ding J, Meng F-J, Zhao H-G. Severe hyperlipemia-induced pseudoerythrocytosis - Implication for misdiagnosis and blood transfusion: A case report and review of literature. *World J Clin Cases* 2020; In press

**Core tip:** Severe hyperlipemia could affect the results of complete blood cell examination by automated blood cell counter. Here, we report a patient with severe hyperlipemia who was at first misdiagnosed as a myeloproliferative neoplasm because of the marked abnormalities in complete blood cell examination. Repeated laboratory tests, by measuring dual blood samples that the chylomicron layer was removed in one sample and was not in another, confirmed that the marked abnormalities was caused by the mistaken readings on automated blood cell counter. This phenomenon may lead to the misjudgment of many laboratory tests and the misinterpretation of blood transfusion indications.

**INTRODUCTION**

Severe hyperlipemia (SHLE) has a significant impact on the results of many kinds of laboratory tests. Complete blood count (CBC) examination by automated blood cell counter (ABCC) is an important measurement for screening abnormalities of blood cells that are triggered by various pathogenic factors in disease diagnosis and for monitoring changes in the treatment of existing hematological conditions. However, CBC results are frequently affected by many intrinsic and extrinsic factors in blood samples, such as in the setting of hypergammaglobulinemia and certain anticoagulants. SHLE can also affect the CBC readings. Here, we report a recurrent pancreatitis patient who was initially misdiagnosed with myeloproliferative neoplasm (MPN) due to mistaken readings by the ABCC, but he was finally diagnosed with SHLE-induced pseudoerythrocytosis. It is speculated that the fat droplets in blood samples of individuals with SHLE are mistakenly identified as blood cells due to the limited parameters of ABCC. This phenomenon may become a potential cause of misdiagnosis of hyperlipemia-related diseases as MPNs and the resultant mistreatment, as reported in this paper. It may also lead to the misinterpretation of indications for blood transfusion in patients with hematological disorders who critically need blood transfusion as supportive treatment, such as in retinoic acid treatment for patients with acute promyelocytic leukemia and in L-asparaginase treatment for patients with acute lymphoblastic leukemia.

**CASE PRESENTATION**

***Chief complaints***

Painful foot numbness for 2 mo and abdominal pain for 2 d.

***History of present illness***

A 33-year-old Chinese male was referred to the emergency department for complaints of painful foot numbness for 2 mo and abdominal pain for 2 d, with the absence of fever, chills, headache, dizziness, cough, expectoration, vomiting, diarrhea, and abnormalities in the urine and feces. Upon physical examination, except for moderate tenderness in his left upper abdomen, no other abnormalities were found. His CBC showed the following results: white blood cell (WBC) count, 11.65 × 109/L; absolute neutrophil count (ANC), 8.85 × 109/L; red blood cell (RBC) count, 4.59 × 1012/L; hemoglobulin (Hb) value, 225 g/L; and platelet (Plt) count, 229 × 109/L. Serum amylase level was 33 U/L. Computerized tomography (CT) examination of his abdomen revealed the presence of adiposis hepatica, without other abnormalities. Ultrasonic inspection of his viscera revealed no obvious abnormalities in the liver, gallbladder, bile duct, pancreas, spleen, kidneys, ureter, or bladder. He was prescribed an antibiotic treatment with etimicin, and his abdominal pain was not relieved. The next day, reexamination of his CBC and serum amylase showed the similar results. He was thought to have erythrocytosis, and his abdominal pain was thought to result from a thrombotic event in the mesenteric vessels, which was probably due to the increased blood viscosity and enhanced Plt activities. So he was admitted to the hematology department.

***History of past illness***

He had a history of acute pancreatitis 2 years previously.

***Physical examination***

His height was at 176 cm; body weight 76.0 kg. His body temperature was at 37.2˚C; breathing rate 22 bp per min; heart rate 86 bp per min; blood pressure 126/78 mmHg. Upon physical examination, except for the bruise-looking appearance and moderate tenderness in his left upper abdomen, no other abnormalities were recorded. Conspicuous mucocutaneous plethora, hemorrhage, jaundice and exanthemata were not presented. No significant signs of nervous system, respiratory system, cardiovascular system, urogenital system and skeletal musculature system were found.

***Laboratory examinations***

On admission, the CBC showed as follows: WBC, 8.97 × 109/L; ANC, 6.66 × 109/L; hematocrit (Hct), 37.6%; RBC, 4.15 × 1012/L; Hb, 204 g/L; mean corpuscular volume (MCV), 90.5 fL; mean corpuscular hemoglobin (MCH), 41.9 pg; mean corpuscular hemoglobin concentration (MCHC), 463 g/L; and Plt, 218 × 109/L. Urinalysis showed ketone bodies 3+, blood 1+, protein 3+, and glucose 3+. Examination of the coagulation profile and biochemical test could not be performed due to SHLE. The tests for hepatitis virus A, B, C, and E and a series of tumor markers were negative. Serum testosterone level was 175 ng/L. Morphological evaluation of the bone marrow (BM) smears and biopsy showed no evidence of MPN. Cytogenetic analysis of BM culture reported a normal karyotype of 46, XY[25]. Gene mutations in B-cell receptor-Abelson murine leukemia viral oncogene homologue 1 (BCR-ABL1), Janus kinase (JAK2), calreticulin (CALR), myeloproliferative leukemia virus (MplV), and colony-stimulating factor 3 receptor (CSF3R) were negative. These laboratory tests did not meet criteria for the diagnosis of MPN.

***Further investigation of the abnormalities in CBC examination***

Having noticed the thick chylomicron layer and dramatically fluctuating CBC results, we speculated that the fat droplets formed by shaking the blood samples in the setting of SHLE were mistakenly identified as blood cells due to the limited parameters of ABCC. Therefore, we removed a large part of the chylomicron layer and then reexamined the CBC and biochemical tests. The CBC showed: WBC, 8.34 × 109/L; ANC, 6.43 × 109/L; RBC, 3.37 × 1012/L; Hb, 118 g/L; and Plt, 164 × 109/L. Biochemical tests showed: Triglycerides (TGs), 3.96 mmol/L; total cholesterol (TC), 9.74 mmol/L; and low density lipoprotein (LDL), 5.67 mmol/L.

To determine whether the erythrocytosis was truly caused by SHLE, we drew dual blood samples, measured them (the chylomicron layer was removed in one sample and was not in another) at the same time, and then compared the CBC results. As we expected, there was a significant difference in the CBC results. While the CBC readings in the sample without removing the layer showed WBC, 10.94 × 109/L; ANC, 8.86 × 109/L; RBC, 4.26 × 1012/L; Hb, 208 g/L; and Plt, 287 × 109/L; the readings in the sample in which a large part of the layer was removed showed WBC, 4.34 × 109/L; ANC, 2.88 × 109/L; RBC, 3.69 × 1012/L; Hb, 114 g/L; and Plt, 215 × 109/L. Subsequently, the repeated tests using this method yielded the similar results (listed in Table 1), confirming the contribution of SHLE to the formation of pseudoerythrocytosis.

***Imaging examinations***

On 5th day of hospitalization, CT reexamination revealed an exudative lesion surrounding the pancreas, in accordance with the diagnosis of pancreatitis.

**FINAL DIAGNOSIS**

After intensive consultation with specialists in gastroenterology, ultrasonography and radiology, a definitive diagnosis was made as recurrent pancreatitis, hyperlipemia and pseudoerythrocytosis.

**TREATMENT**

After the definitive diagnosis of recurrent pancreatitis, hyperlipemia and pseudoerythrocytosis was made, he was transferred to the gastroenterology department and was treated for his pancreatitis according to guidelines for diagnosis and treatment of chronic pancreatitis(Nanjing, 2018).

**OUTCOME AND FOLLOW-UP**

This patient was treated in the gastroenterology department for his pancreatitis, and the serum level of TGs, TC, and LDL gradually decreased. Along with the decreasing serum level of TGs, TC, and LDL, the results of CBC examination were normalized with the exception of a mild anemia.

**DISCUSSION**

MPNs, including chronic myelogenous leukemia, 8P11 myeloproliferative syndrome, chronic eosinophilic leukemia, polycythemia vera (PV), essential thrombocythemia, primary myelofibrosis, chronic neutrophilic leukemia, systemic mastocytosis, and chronic basophilic leukemia, are clonal diseases resulting from the uncontrolled proliferation of hematopoietic stem and progenitor cells without obvious differential arrest and dysplasia, leading to the hypercellular BM and the increased periphery blood (PB) cell counts. Diagnosis and classification of MPNs are primarily based on the morphological examination of the BM and PB cells. These seemingly normal-appearance blood cells are caused by gain of function reciprocal translocations and mutations in genes encoding receptor tyrosine kinases or their c-Jun N-terminal kinase-signal transducer and activator of transcription (JNK-STAT)-associated signal pathway components. Constitutive activation of the JNK-STAT signaling pathway is responsible for excessive and autonomous blood cell production[1-3]. MPN-associated fusion genes caused by the recurrent rearrangements frequently involved the genes ABL1, platelet-derived growth factor receptor-a *(*PDGFR-a), PDGFR-β, and fibroblast growth factor receptor-1, whereas MPN-associated gene mutations frequently involved the genes JAK2, CALR*,* MplV, CSF3R*,* and the stem cell growth factor receptor gene CD117[1-7].

In this paper, we described a pancreatitis patient who was at first misdiagnosed as erythrocytosis (presumptive diagnosis of PV) because of the markedly elevated Hb level at presentation due to the mistaken readings of the ABCC in the evaluation of complete blood cells, but he was eventually diagnosed with SHLE-induced pseudoerythrocytosis. The purpose of reporting this patient and the diagnostic process is for the doctors to call attention to the comprehensive and objective evaluation of the CBC results on ABCC, especially in the setting of SHLE, a very common laboratory finding in clinical practice.

The World Health Organization diagnostic criteria for PV is based on the elevated Hb (> 16.5 g/dL in men or > 16.0 g/dL in women) or Hct (> 49% in men or > 48% in women) levels, with the prominent erythroid, granulocytic and megakaryocytic proliferation in BM biopsy, incorporating the presence of JAK2V617F or JAK2 exon 12 mutation[2,3]. In clinical practice, the elevated Hb level is the most commonly used parameter for the diagnosis and grading of anemia and erythrocytosis. In this patient, the markedly elevated Hb level at presentation (up to 225 g/L = 22.5 g/dL) strongly indicated the possibility of the presence of PV. However, the following laboratory investigations, including morphological examination, cytogenetic and molecular analysis, did not meet criteria for the diagnosis of any kind of MPN.

The CBC profile in this patient revealed a noteworthy feature: WBCs, ANCs, Hb, MCH, and MCHC were all increased to some degree, with the presence of markedly elevated Hb and MCHC level, but the absence of a paralleled increase in RBCs and Hct was the most prominent feature. The dramatically fluctuating and obviously discrepant CBC results among Hct, RBCs, Hb, MCV, MCH, and MCHC were easily identified. In addition, there was a conspicuous chylomicron layer floating on the surface of the blood samples. Having noticed these, we removed a large part of the chylomicron layer and then evaluated the CBC readings. After removing a large part of the chylomicron layer, WBCs, ANC, Hb, MCH, MCHC, and Plt were all decreased to varying degrees. We presumed that the erythrocytosis was the result of fatty droplets that are mistakenly identified as blood cells due to the limited parameters of ABCC. So a laboratory investigation was performed by drawing dual blood samples, measuring them (the chylomicron layer was removed in one sample and was not in another) at the same time, and comparing the CBC results. As we expected, there was a significant difference in the CBC results. This laboratory investigation provided strong evidence to conform the contribution of SHLE to the markedly elevated Hb and MCHC levels in CBC examination in this patient.

Hyperlipemia, one of the essential compartments of metabolic syndrome, combination of genetic background and environmental factors in its pathogenesis, is a common laboratory finding in biochemical tests. SHLE could be the complication of various diseases mainly involving diseases in the cardiovascular system, endocrine system, liver, pancreas and kidneys, in which hyperlipemia may the consequence of metabolic abnormalities and play an essential role in the pathogenesis of targeted tissue damages[8-21]. In the genetically predisposed individuals, systemic inflammatory conditions and dietary regimen may be the major environmental factors to influence the lipid metabolism and insulin resistance[22-27]. SHLE sometimes occurs in the natural history or in the treatment of certain hematological diseases, such as in tyrosine kinase inhibitor treatment for patients with MPNs, retinoic acid treatment for patients with acute promyelocytic leukemia and L-asparaginase treatment for patients with acute lymphoblastic leukemia[28-32]. It is well known that SHLE have an unexpected impact on many kinds of laboratory tests, making the diagnostic process more complicated and perplexed. SHLE may also affect the CBC results on the ABCC.

To date, there are too few reports that have documented the erythrocytosis to be complicated by hyperlipemia in that erythrocytosis was in association with the high frequency of cardiovascular events and the incitation of pancreatitis[33-38]. However, it has never been recognized that SHLE can lead to the induction of pseudoerythrocytosis. The higher frequency of erythrocytosis in the context of SHLE strongly indicates that some patients may be misdiagnosed as MPNsdue to mistaken readings by the ABCCs[38] as reported in the present case. The high frequency of cardiovascular events and the induction of pancreatitis in this setting may lie in the hyperlipemia-related diseases themselves which may result from the dysregulated metabolic activities and the co-existing inflammatory conditions[21-27].

The impact of SHLE on the CBC results may be overlooked because hyperlipemia patients seldom see the hematologists, and thus, this phenomenon has not been rigorously investigated. Differential diagnosis between true erythrocytosis and pseudoerythrocytosis in the setting of hyperlipemia may be simply by intellectual and comprehensive analysis of the reasonableness of each CBC results (especially by the observation whether the Hb level is in parallel to the Hct value or not) at first and by comparing the CBC results between blood samples with and without removal of the chylomicron layer subsequently by a means employed in this paper. In addition, the elevated even normal serum levels of total, LDL and high density lipoprotein cholesterol are biased to the diagnosis of hyperlipemia-induced pseudoerythrocytosis or have an co-existence of MPNs and hyperlipemia-related diseases[39-42]. However, this investigation is limited by the changes in the value of blood sample, and these changes may make it difficult to interpret the true Hb concentration in patient’s blood. Another question is what concentration and components of blood lipids are able to significantly affect the CBC readings on the ABCC. So, this investigation merely provides an information that SHLE could affect the CBC results measured by ABCC, and how to correctly measure the true Hb concentration in patient’s blood warrants further investigations.

Recognizing this phenomenon helps better understand the CBC results on ABCC in the context of hyperlipemia, especially in individuals with SHLE. MPNs are clonal diseases characterized by the constitutive activation of genes in growth factor receptors or their signal pathway components, resulting in the uncontrolled proliferation of hematopoietic cells. Treatment of MPNs differ completely from that of hyperlipemia-related diseases. Therefore, the differential diagnosis between these diseases is very important as demonstrated in this case. In addition, SHLE sometimes occurs in the treatment of hematological malignancies, and this may lead to the misinterpretation of transfusion indications, which may result in serious consequences such as severe ischemic episodes and severe bleeding events.

**CONCLUSION**

SHLE could significantly affect the CBC results on ABCC. This phenomenon may lead to the misdiagnosis of hyperlipemia-related diseases as MPNs and the resultant mistreatment. It may also lead to the misinterpretation of transfusion indications in the treatment of hematopoietic diseases.

When a patient presents with a high level of Hb and makes a presumptive diagnosis of MPNs, it is very necessary to carefully examine the blood samples, to correctly evaluate the CBC results and to look up the biochemical tests. The appearance of a chylomicron layer in blood samples, the discrepant results in CBC examination and the elevated serum levels of TGs, TC, and LDL strongly indicate the possible diagnosis of pseudoerythrocytosis. In this setting, investigations are warranted as showed in our paper, and the underlying diseases must be diagnosed as soon as possible so as to let the patient receive prompt and proper treatments. In patients with hematological diseases in the setting of hyperlipemia, the blood transfusion indications must be adjusted according to the patient’s symptoms rather than are dependent merely on the Hb levels or the Plt counts.

**ACKNOWLEDGMENTS**

The authors would like to thank Bin Li (Department Gastroenterology, The Affiliated Hospital of Qingdao University), Xiu-Shuan Feng (Department Radiology, The Central Hospital of Qingdao West Coast New Area), and Ming Bai (Department Ultrasonography, The Central Hospital of Qingdao West Coast New Area) for assistance in the analysis of laboratory and imaging examination.

**REFERENCES**

1 **Lichtman MA**, Prchal JF, Prchal JT, Beer PA, Green AR, Liesveld JL. Malignant myeloid diseases. In: Williams Hematology. 9th ed. New York: The McGraw-Hill Companies; 2016; 1275-1399, 1437-1490

2 **Arber DA**, Orazi A, Hasserjian R, Thiele J, Borowitz MJ, Le Beau MM, Bloomfield CD, Cazzola M, Vardiman JW. The 2016 revision to the World Health Organization classification of myeloid neoplasms and acute leukemia. *Blood* 2016; **127**: 2391-2405 [PMID: 27069254 DOI: 10.1182/blood-2016-03-643544]

3 **Barbui T**, Thiele J, Gisslinger H, Kvasnicka HM, Vannucchi AM, Guglielmelli P, Orazi A, Tefferi A. The 2016 WHO classification and diagnostic criteria for myeloproliferative neoplasms: document summary and in-depth discussion. *Blood Cancer J* 2018; **8**: 15 [PMID: 29426921 DOI: 10.1038/s41408-018-0054-y]

4 **Jang MA**, Choi CW. Recent insights regarding the molecular basis of myeloproliferative neoplasms. *Korean J Intern Med* 2020; **35**: 1-11 [PMID: 31778606 DOI: 10.3904/kjim.2019.317]

5 **Li B**, Gale RP, Xiao Z. Molecular genetics of chronic neutrophilic leukemia, chronic myelomonocytic leukemia and atypical chronic myeloid leukemia. *J Hematol Oncol* 2014; **7:** 93 [PMID: 25498990 DOI: 10.1186/s13045-014-0093-1]

6 **Shomali W**, Gotlib J. World Health Organization-defined eosinophilic disorders: 2019 update on diagnosis, risk stratification, and management. *Am J Hematol* 2019; **94**: 1149-1167 [PMID: 31423623 DOI: 10.1002/ajh.25617]

7 **Pardanani A**. Systemic mastocytosis in adults: 2019 update on diagnosis, risk stratification and management. *Am J Hematol* 2019; **94**: 363-377 [PMID: 30536695 DOI: 10.1002/ajh.25371]

8 **Zafar U,** Khaliq S, Ahmad HU, Manzoor S, Lone KP. Metabolic syndrome: an update on diagnostic criteria, pathogenesis, and genetic links. *Hormones (Athens)* 2018; **17**: 299-313 [PMID: 30171523 DOI: 10.1007/s42000-018-0051-3]

9 **Williams RR**, Hopkins PN, Hunt SC, Schumacher MC, Elbein SC, Wilson DE, Stults BM, Wu LL, Hasstedt SJ, Lalouel JM. Familial dyslipidaemic hypertension and other multiple metabolic syndromes. *Ann Med* 1992; **24**: 469-475 [PMID: 1485941 DOI: 10.3109/07853899209166998]

10 **Mikolasevic I**, Milic S, Turk Wensveen T, Grgic I, Jakopcic I, Stimac D, Wensveen F, Orlic L. Nonalcoholic fatty liver disease - A multisystem disease? *World J Gastroenterol* 2016; **22**: 9488-9505 [PMID: 27920470 DOI: 10.3748/wjg.v22.i43.9488]

11 **Chiang JY**. Bile acid metabolism and signaling. *Compr Physiol* 2013; **3**: 1191-1212 [PMID: 23897684 DOI: 10.1002/cphy.c120023]

12 **Targher G**, Byrne CD. Non-alcoholic fatty liver disease: an emerging driving force in chronic kidney disease. *Nat Rev Nephrol* 2017; **13**: 297-310 [PMID: 28218263 DOI: 10.1038/nrneph.2017.16]

13 **Wang CS**, Greenbaum LA. Nephrotic Syndrome. *Pediatr Clin North Am* 2019; **66**: 73-85 [PMID: 30454752 DOI: 10.1016/j.pcl.2018.08.006]

14 **Vaziri ND**. Disorders of lipid metabolism in nephrotic syndrome: mechanisms and consequences. *Kidney Int* 2016; **90**: 41-52 [PMID: 27165836 DOI: 10.1016/j.kint.2016.02.026]

15 **Khatua B,** El-Kurdi B, Singh VP. Obesity and pancreatitis. *Curr Opin Gastroenterol* 2017; **33**: 374-382 [PMID: 28719397 DOI: 10.1097/MOG.0000000000000386]

**16 Guo YY**, Li HX, Zhang Y, He WH. Hypertriglyceridemia-induced acute pancreatitis: progress on disease mechanisms and treatment modalities. *Discov Med* 2019; **27**: 101-109 [PMID: 30939294]

17 **Ferraù F**, Korbonits M. Metabolic Syndrome in Cushing's Syndrome Patients. *Front Horm Res* 2018; **49**: 85-103 [PMID: 29894989 DOI: 10.1159/000486002]

18 **Nieman LK**. Hypertension and Cardiovascular Mortality in Patients with Cushing Syndrome. *Endocrinol Metab Clin North Am* 2019; **48**: 717-725 [PMID: 31655772 DOI: 10.1016/j.ecl.2019.08.005]

19 **Delitala AP,** Scuteri A, Maioli M, Mangatia P, Vilardi L, Erre GL. Subclinical hypothyroidism and cardiovascular risk factors. *Minerva Med* 2019; **110**: 530-545 [PMID: 31726814 DOI: 10.23736/S0026-4806.19.06292-X]

20 **Jabbar A**, Pingitore A, Pearce SH, Zaman A, Iervasi G, Razvi S. Thyroid hormones and cardiovascular disease. *Nat Rev Cardiol* 2017; **14**: 39-55 [PMID: 27811932 DOI: 10.1038/nrcardio.2016.174]

21 **Navina S**, Acharya C, DeLany JP, Orlichenko LS, Baty CJ, Shiva SS, Durgampudi C, Karlsson JM, Lee K, Bae KT, Furlan A, Behari J, Liu S, McHale T, Nichols L, Papachristou GI, Yadav D, Singh VP. Lipotoxicity causes multisystem organ failure and exacerbates acute pancreatitis in obesity. *Sci Transl Med* 2011; **3**: 107ra110 [PMID: 22049070 DOI: 10.1126/scitranslmed.3002573]

22 **Jiang N**, Li Y, Shu T, Wang J. Cytokines and inflammation in adipogenesis: an updated review. *Front Med* 2019; **13**: 314-329 [PMID: 30066061 DOI: 10.1007/s11684-018-0625-0]

23 **Kalupahana NS**, Moustaid-Moussa N, Claycombe KJ. Immunity as a link between obesity and insulin resistance. *Mol Aspects Med* 2012; **33**: 26-34 [PMID: 22040698 DOI: 10.1016/j.mam.2011.10.011]

24 **Bedimo R**, Abodunde O. Metabolic and Cardiovascular Complications in HIV/HCV-Co-infected Patients. *Curr HIV/AIDS Rep* 2016; **13**: 328-339 [PMID: 27595755 DOI: 10.1007/s11904-016-0333-9]

25 **Akhtar DH,** Iqbal U, Vazquez-Montesino LM, Dennis BB, Ahmed A. Pathogenesis of Insulin Resistance and Atherogenic Dyslipidemia in Nonalcoholic Fatty Liver Disease. *J Clin Transl Hepatol* 2019; **7**: 362-370 [PMID: 31915606 DOI: 10.14218/JCTH.2019.00028]

26 **Stahel P**, Xiao C, Nahmias A, Lewis GF. Role of the Gut in Diabetic Dyslipidemia. *Front Endocrinol (Lausanne)* 2020; **11**: 116 [PMID: 32231641 DOI: 10.3389/fendo.2020.00116]

**27 Fousekis FS**, Theopistos VI, Katsanos KH, Christodoulou DK. Pancreatic Involvement in Inflammatory Bowel Disease: A Review. *J Clin Med Res* 2018; **10**: 743-751 [PMID: 30214645 DOI: 10.14740/jocmr3561w]

28 **Rea D**, Mirault T, Cluzeau T, Gautier JF, Guilhot F, Dombret H, Messas E. Early onset hypercholesterolemia induced by the 2nd-generation tyrosine kinase inhibitor nilotinib in patients with chronic phase-chronic myeloid leukemia. *Haematologica* 2014; **99**: 1197-1203 [PMID: 24658819 DOI: 10.3324/haematol.2014.104075]

29 **Fujiwara H**, Umeda Y, Yonekura S. Cerebellar infarction with hypertriglyceridemia during all-trans retinoic acid therapy for acute promyelocytic leukemia. *Leukemia* 1995; **9**: 1602-1603 [PMID: 7658733]

30 **Gu W**, Hu S, He B, Qiu G, Ma J, Chen Z. Metabolites of acute promyelocytic leukemia cells participate in contributing to hypertriglyceridemia induced by all-trans retinoic acid. *Leuk Res* 2009; **33**: 592-594 [PMID: 18722659 DOI: 10.1016/j.leukres.2008.07.017]

31 **Nesheli HM**, Tamaddoni A, Nesheli MM, Yahyai A, Khabiri F, Hosseinzadeh F, Moghaddam TG. L-asparaginase induced hyperlipidaemia in acute lymphoblastic leukaemia. *J Pak Med Assoc* 2013; **63**: 324-326 [PMID: 23914630]

32 **Lau KM**, Saunders IM, Goodman A. Pegaspargase-induced hypertriglyceridemia in a patient with acute lymphoblastic leukemia. *J Oncol Pharm Pract* 2020; **26**: 193-199 [PMID: 30823860 DOI: 10.1177/1078155219833438]

33 **Santer MA Jr**, Waldmann TA, Fallon HJ. Erythrocytosis and hyperlipemia as manifestations of hepatic carcinoma. *Arch Intern Med* 1967; **120**: 735-739 [PMID: 4293747]

34 **Chu CW**, Hwang SJ, Luo JC, Tsay SH, Li CP, Chang FY, Lee SD, Lui WY, Chiang JH. Manifestations of hypercholesterolaemia, hypoglycaemia, erythrocytosis and hypercalcaemia in patients with hepatocellular carcinoma: report of two cases. *J Gastroenterol Hepatol* 1999; **14**: 807-810 [PMID: 10482434 DOI: 10.1046/j.1440-1746.1999.01955.x]

35 **Jonsson V**, Manthorpe R. Hyperlipaemia following phlebotomies. Hyperlipaemia of Fredrickson's type V after phlebotomies for control of erythrocytosis. *Atherosclerosis* 1974; **20**: 89-92 [PMID: 4376407 DOI: 10.1016/0021-9150(74)90082-3]

36 **Costantini N**, Mameli A, Marongiu F. Plasmapheresis for Preventing Complication of Hypertriglyceridemia: A Case Report and Review of Literature. *Am J Ther* 2016; **23**: e288-e291 [PMID: 25285671 DOI: 10.1097/MJT.0000000000000079]

37 **Ramírez-Bueno A**, Salazar-Ramírez C, Cota-Delgado F, de la Torre-Prados MV, Valdivielso P. Plasmapheresis as treatment for hyperlipidemic pancreatitis. *Eur J Intern Med* 2014; **25:** 160-163 [PMID: 24012324 DOI: 10.1016/j.ejim.2013.08.701]

38 **Benjamin D**, Yeshurun D, Charnilas J, Pinkhas J. Hyperlipidemia and myocardial infarction among 118 patients with polycythemia vera. *Am J Med Sci* 1978; **276**: 23-26 [PMID: 215033 DOI: 10.1097/00000441-197807000-00002]

39 **Gilbert HS**, Ginsberg H, Fagerstrom R, Brown WV. Characterization of hypocholesterolemia in myeloproliferative disease. Relation to disease manifestations and activity. *Am J Med* 1981; **71**: 595-602 [PMID: 7282748 DOI: 10.1016/0002-9343(81)90212-6]

40 **Ginsberg H**, Gilbert HS, Gibson JC, Le NA, Brown WV. Increased low-density-lipoprotein catabolism in myeloproliferative disorders. *Ann Intern Med* 1982; **96**: 311-316 [PMID: 7059093 DOI: 10.7326/0003-4819-96-3-311]

41 **Ginsberg HN**, Le NA, Gilbert HS. Altered high density lipoprotein metabolism in patients with myeloproliferative disorders and hypocholesterolemia. *Metabolism* 1986; **35**: 878-882 [PMID: 3747843 DOI: 10.1016/0026-0495(86)90232-5]

42 **Zhou P,** Hatziieremia S, Elliott MA, Scobie L, Crossan C, Michie AM, Holyoake TL, Halbert GW, Jørgensen HG. Uptake of synthetic Low Density Lipoprotein by leukemic stem cells--a potential stem cell targeted drug delivery strategy. *J Control Release* 2010; **148**: 380-387 [PMID: 20869412 DOI: 10.1016/j.jconrel.2010.09.016]

**Footnotes**

**Informed consent statement:** Informed written consent was obtained from the patient for publishing this report and any accompanying laboratory data.

**Conflict-of-interest statement:** The authors declare that they have no conflicts of interest.

**CARE Checklist (2016) statement:** The authors have read the CARE Checklist (2016), and the manuscript was prepared and revised according to the CARE Checklist (2016).

**Open-Access:** This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/Licenses/by-nc/4.0/

**Manuscript source:** Unsolicited manuscript

**Peer-review started:** May 8, 2020

**First decision:** July 25, 2020

**Article in press:**

**Specialty type:** Medicine, research and experimental

**Country/Territory of origin:** China

**Peer-review report’s scientific quality classification**

Grade A (Excellent): A

Grade B (Very good): B

Grade C (Good): 0

Grade D (Fair): 0

Grade E (Poor): 0

**P-Reviewer:** Neninger E **S-Editor:** Huang P **L-Editor:** Filipodia **P-Editor:**

**Table 1 Complete blood count results before and after removing the chylomicron layer**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Times No.** | **WBCs** | **ANC** | **RBCs** | **Hb** | **Hct** | **Plts** |
| 1 | BRL | 10.94 | 8.86 | 4.26 | 208 | 36.20 | 287 |
| ARL | 4.83 | 2.88 | 3.69 | 114 | 33.70 | 215 |
| 2 | BRL | 9.85 | 7.08 | 4.63 | 221 | 40.30 | 242 |
| ARL | 4.49 | 2.10 | 4.37 | 132 | 39.50 | 177 |
| 3 | BRL | 10.72 | 8.76 | 4.23 | 188 | 36.30 | 326 |
| ARL | 4.98 | 2.93 | 3.76 | 115 | 34.10 | 231 |

WBC: White blood cell, × 109/L; ANC: Absolute neutrophil count, × 109/L; RBC: Red blood cell, × 1012/L; Hb: Hemoglobulin, g/L; Hct: Hematocrit, %; Plt: Platelet, × 109/L; BRL: Before removing the chylomicron layer; ARL: After removing the chylomicron layer.