Novel Simple Approach for Differentiating Concentrated or Diluted Blood Samples, Hematological Disorders and Organ Dysfunctions in Acute Care Settings-A Global Perspective

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Abstract: Dilution or concentration of blood sample during patient receiving intravenous fluids or at presentation of disease with severe volume depletion is common clinical scenario. There are various gold standard advanced technological time-consuming elective methods like radioactive chromium method, radioactive iodine method, etc which are useful for diagnosis of dilution or concentration. But during routine examination especially at smaller peripheral centres or low-income countries where these facilities are lacking, it is difficult to check that either sample is diluted, concentrated or due to altered pathological diseased state as both will give modified results than the actual state of the patient's current pathophysiological condition. In acute care trauma settings, intensive or critical care units and high dependency units with critically ill patients many of them having multiple organ dysfunction and associated co-morbidities, many of the decisions about their care will be based on the results of hematological and biochemical profile and the time is very crucial to take decision and act in immediately. The simple innovative approach described allows quick and accurate decision making based on correct interpretation of the investigative findings.

Keywords: Acute myeloid leukemia, Acute infections, Cancer chemotherapy, Dilutional anemia, Liver disease, Kidney disease, Pathological anemia.

INTRODUCTION

There is an increasing incidence of rare blood disorders due to introduction of molecular genetics methods into diagnostics, prolonged overall survival of patients and increasing migration from areas with endemic occurrence of these diseases [1]. In order to diagnose hematological disorders, usually the starting point in outpatient's department is taking detailed medical history followed by full comprehensive physical examination and performing a complete blood count [2]. However, when such disorder present in acute care settings in emergency department, intensive care units, high dependency units and acute care wards; interpretation of the blood test results becomes compounded by various intravenous fluid therapy being given and needs methods to differentiate dilutional from pathological disorders or disease states due to hematological disease or liver and kidney diseases.

This is very true about the patients with some co-morbidity or treatment related therapy of post major trauma or operative patients with major surgery, severe infections, chemotherapy for oncology patients, and critically ill patients receiving significant amounts of intravenous fluids. But generally, we discover blood disorders through performing a complete blood count which tells us about red blood cells, white blood cells, platelets, and hemoglobin levels. However, in a complex patient with multiple co-morbidities in an emergency setting especially being treated with high volumes of intravenous fluid therapy, bedside clinical help and support using simple but effective methods allows quick and precise decision making.

MATERIAL AND METHODS

The patient population is in acute care settings such as emergency department, level 1 tertiary trauma centres, intensive care units, critical care units, Covid 19 units with severe disease with underlying hematological disorders and associated co-morbidities. The timing could be at initial presentation, during resuscitation, subsequent treatment or in wards or office settings with global perspective in peripheral

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small hospitals in developed countries and low or middle income countries with limited resources.

In order to differentiate them, we divide patient in 3 groups

- Patient with normal liver & renal function
- Patient with underlying liver disease by performing liver function test
- Patient with underlying kidney disease by performing renal function test

PATIENT WITH NORMAL LIVER & RENAL FUNCTION TEST

In these patients we can check either blood sample is relatively diluted as compared to first sample by doing simple calculation.

Ratio of = (hemoglobin in gram/decilitre)/(serum albumin in gram/decilitre)

EXPLANATION

Patient of AML or any underlying pathological condition had done CBC containing haemoglobin level and other serological report containing serum albumin level. Let's assume haemoglobin = 12 g/dL & serum albumin = 4 g/dL. Ratio = 12/4 = 3

On second report if patient had underlying pathological condition like blood cell production defect or blood cell destruction like haemolysis only hemoglobin value will be decreased, serum albumin may remain unchanged so ratio must be decreased. Let's assume hemoglobin in second report = 9 g/dL & serum albumin = 4 g/dL. Ratio in second report = 9/4 = 2.25 g/dL = decreased means decreased due to defective production / increased destruction.

On second report if blood was diluted by given IV fluids, haemoglobin & serum albumin concentration both will decrease simultaneously so that ratio of both concentration remains same. Let's assume blood diluted by given IV fluids, in second report hemoglobin = 9 g/dL & serum albumin = 3 g/dL, ratio = 9/3 =3, which is same as first report so blood sample may be diluted by giving IV fluids.

PATIENT WITH UNDERLYING LIVER DISEASE BY PERFORMING LIVER FUNCTION TEST

As albumin is synthesized by liver, any condition involving liver may affect ratio of hemoglobin / serum albumin. So, any other serologic value like serum potassium level which is not affected by liver disease could be taken in account on behalf of serum albumin.

Ratio for patients with underlying liver disease = hemoglobin / serum potassium

PATIENT WITH UNDERLYING KIDNEY DISEASE BY PERFORMING RENAL FUNCTION TEST

Serum albumin & almost all other serological values are changed in underlying renal disease. It is difficult to differentiate sample is diluted or diseased by calculating ratio.

RESULTS

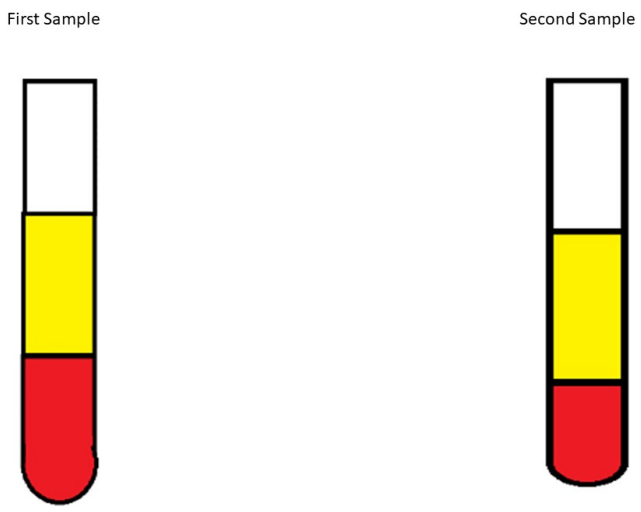

Figure 1: First and second sample.

New Approach

Inject dye which does not leave blood vessels. Take blood sample. Centrifuge sample.

First sample

Note RBC mass

Take serum sample apply monochromatic light note light transmitted

In Second time sample take more blood centrifuge

Note that RBC mass on second sample is decreased. Do simple math calculation to equalize both sided RBC mass like

On P ml of blood first sample gives X mm height & second sample gives Y mm of height. To achieve X mm height in second sample blood sample required in ml = X * P / Y

Take (X * P/Y ml) blood in third tube centrifuge it

Now first & third tube contains same RBC mass.

Take serum sample apply monochromatic light note transmitted light

According to Beer's law of colorimetry, we can calculate ratio of both dye's concentration by measuring transmitted light by sensors

We can calculate height of both samples' plasma level.

If patient's blood was diluted by giving IV fluids, concentration of dye decreases in third sample as concentration is inversely proportional to volume of solvent. But we are equalling RBC mass on both side by taking more blood volume in sample so mass of dye in both samples must be equal.

Mass 1 = mass 3

Concentration = mass / volume

So, mass = concentration * volume

Concentration 1 * volume 1 = concentration 3 * volume 3

(concentration 1)/ (concentration 3) = (volume 3)/(volume 1)

Ratio of concentration is calculated by Beer's law of spectrophotometry (Thomas G. Mayerhöfer, 2019).

Ratio of volume is calculated by height in centrifugation tube

If both side ratio is equal, it must be dilution.

If both side ratio is not equal evaluate for RBC production defect or increased haemolysis.

DISCUSSION

Recent Covid 19 pandemic has seen pediatric multisystem inflammatory syndrome [MIS-C] and the adult severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) presenting acutely in serious condition in emergency departments associated with elderly, obese, diabetic, hypertensive and hypercho-lesterolemia; cancer, autoimmune, or other conditions requiring immunosuppression [3, 4].

Recent studies have shown the relationship of fluid overload with adverse outcomes; hence, manage and optimization of fluid balance becomes a central component of the management of critically ill patients [5, 6]. Acute myeloid leukaemia (AML) is a condition in which myeloblast count rapidly increase in bone marrow, so normal functioning erythrocyte precursors are decreased in number resulting in reduced blood cell count. Patient of AML are also given IV fluids daily. Blood sampling is also done daily for assessment of AML If CBC report displays low blood cell count it is difficult to say that either count is decreased by AML progression or IV fluids have diluted blood sample so it is displaying low blood cell count.

It is utmost important to check that either blood cell count is really increased or decreased or we are getting false low count because treatment of AML patient depends on 2 factors like patient has low blood count so he developed severe infection due to like pneumonia in which case chemotherapy is not given because anti-cancer drugs have bone marrow suppressive effect = immunosuppressive effect so it will flare up infection like pneumonia and patient will die due to pneumonia than AML or patient has sufficient blood count but we are getting false low count due to dilution by given IV fluids in which case give chemotherapy because patient has sufficient blood cells to counter infection [7].

As derived by Max Planck in 1903 from dispersion theory, Beer's law has a fundamental limitation. The concentration dependence of absorbance can deviate from linearity, even in the absence of any interactions or instrumental nonlinearities. Integrated absorbance, not peak absorbance, depends linearly on concentration. Thus, concentration analysis of complex

samples, such as layered and/or anisotropic materials, in which Beer's law cannot be applied, can be achieved using dispersion analysis [8]'

According to a recent study by Johns Hopkins, more than 250,000 people in the United States die every year because of medical mistakes, making it the third leading cause of death after heart disease and cancer [9-12]. Makary defines a death due to medical error as one that is caused by inadequately skilled staff, error in judgment or care, a system defect or a preventable adverse effect. This includes computer breakdowns, mix-ups with the doses or types of medications administered to patients and surgical complications that go undiagnosed. For effective treatment, accurate detection of the actual current state of the patient is crucial and in acute care settings time is really an essence. Teaching medical, nursing, physician assistants and technicians and interns, junior residents and junior nurses such simple innovative, accurate and fast technique will allow reduction in mortality and morbidity in the long run.

CONCLUSION

We believe that the interpretation of results of blood samples in acute care setting at presentation and subsequent therapeutic level especially in patients with multiple associated co-morbidities and hematological and or multiple organ dysfunctions may be improved using our innovative, simple yet accurate technique of differentiating these various scenarios and precisely take good decision leading to recovery of the patient and discovery of the unique technique described. By doing simple calculation we can avoid misinterpretation of blood report and provide optimum treatment to patient. It may help reduce the third leading cause of death in USA which is due to medical errors. This technique is particularly versatile in acute care settings and with global perspective it can be applied anywhere in the globe

COMPLIANCE WITH ETHICAL STANDARDS

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Conflict of Interest

The authors have no conflict of interest to declare. No funding source was involved in this study.

Ethical Approval

All procedures performed on human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed Consent

Informed consent was obtained from the parents and all the relatives involved prior to all the procedures.

Parents and all involved parties were informed about the procedure**.**

ABBREVIATIONS

AML - acute myeloid leukemia; IV - intravenous; CBC - complete blood count; g - gram; dL-decilitre; mL-millilitre; RBC - red blood cell

REFERENCES

[1] Válka J, Čermák J. Differential diagnosis of anemia. Vnitr Lek. 2018; 64(5): 468-475. English. https://doi.org/10.36290/vnl.2018.067

[2] Thachil J, Bates I. Approach to the Diagnosis and Classification of Blood Cell Disorders. Dacie and Lewis Practical Haematology. 2017: 497-510. https://doi.org/10.1016/B978-0-7020-6696-2.00023-0

[3] Son MBF, Friedman K, COVID-19: Multisystem inflammatory syndrome in children (MIS-C) clinical features, evaluation, and diagnosis. UpToDate for Wolters Kluwer, https://www.uptodate.com/contents/covid-19-multisystem-inflammatory-syndrome-in-children-mis-c-clinical-features-evaluation-and-diagnosis#H3106676936 Mar 07, 2023.

[4] World Health Organization. Director-General's remarks at the media briefing on 2019-nCoV on 11 February 2020. Available at: http://www.who.int/dg/speeches/detail/who-director-general-s-remarks-at-the-media-briefing-on-2019-ncov-on-11-february-2020 (Accessed on February 12, 2020).

[5] laure-Del Granado R, Mehta RL. Fluid overload in the ICU: evaluation and management. BMC Nephrol 2016; 17: 109. https://doi.org/10.1186/s12882-016-0323-6

[6] Iqbal MS, Tabassum A, Arbaeen AF, Qasem AH, Elshemi AG, Almasmoum H. Preanalytical Errors in a Hematology Laboratory: An Experience from a Tertiary Care Center. Diagnostics (Basel). 2023; 13(4): 591. https://doi.org/10.3390/diagnostics13040591

[7] Silver HM, Seebeck MA, Cowett RM, Patterson KY, Veillon C. Red cell volume determination using a stable isotope of chromium. J Soc Gynecol Investig. 1997; 4(5): 254-8. https://doi.org/10.1177/107155769700400506

[8] Mayerhöfer TG, Pipa AV, Popp J. Beer's Law-Why Integrated Absorbance Depends Linearly on Concentration. Chemphyschem. 2019; 20(21): 2748-2753. https://doi.org/10.1002/cphc.201900787

[9] Study Suggests Medical Errors Now Third Leading Cause of Death in the U.S. https://www.hopkinsmedicine.org/news/media/releases/study_suggests_medical_errors_now_third_leading_cause_of_death_in_the_us

[10] Makary MA, Daniel M. Medical error-the third leading cause of death in the US. BMJ. 2016; 353: i2139. PMID: 27143499. https://doi.org/10.1136/bmj.i2139

[11] Gianoli GJ. Medical Error Epidemic Hysteria. Am J Med. 2016; 129(12): 1239-1240. Epub 2016 Jul 16. PMID: 27430404. https://doi.org/10.1016/j.amjmed.2016.06.037

[12] Roel E, García-Díez M, Borrás Bermejo B. Errores médicos, la tercera causa de muerte en Estados Unidos? [Medical errors, the third leading cause of death in the United States?]. J Healthc Qual Res. 2019; 34(6): 339-341. https://doi.org/10.1016/j.jhqr.2019.06.005

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