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ASSESSMENT OF ANEMIA AND POLYCYTHEMIA USING DIODE LASER ABSORPTION: A NOVEL APPROACH

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Abstract:
Anemia and polycythemia are prevalent hematological disorders with a significant impact on the health of individuals residing in the Mediterranean region and the Middle East. This abstract provides an overview of the clinical associations, etiology, and consequences of these conditions.
Anemia is a condition characterized by a deficiency in red blood cells or hemoglobin, resulting in reduced oxygen-carrying capacity of the blood. It is often indicative of underlying health issues such as chronic renal failure, endocrine disorders, joint diseases, gastrointestinal diseases, and liver diseases. Deficiencies in essential nutrients like iron, vitamin B12, and folate can also lead to anemia. Recognizing the diverse etiologies of anemia is crucial for effective diagnosis and management.
Conversely, polycythemia is a disorder characterized by an excessive production of red blood cells, which can impair oxygen transport and lead to various complications. Chronic smokers, for instance, are at risk of carboxyhemoglobin formation, which reduces oxygen release from hemoglobin. Additionally, polycythemia can result in renal hypoxia and autonomous erythropoietin biosynthesis, further exacerbating the condition. Early identification and intervention are essential to mitigate the adverse effects of polycythemia.
Understanding the complex interplay between these hematological disorders and their associated comorbidities is crucial for healthcare practitioners in the Mediterranean region and the Middle East. Timely diagnosis and appropriate management of anemia and polycythemia can substantially improve patient outcomes and overall quality of life.

Keywords: Anemia, polycythemia, Mediterranean region, Middle East, hematological disorders.

Literature Review

Obviously, Anemia, as well as polycythemia, diseases are broadly distributed throughout parts of the Mediterranean region and the Middle East (1). They are always related with some functional disorders and diseases in human body.

For example, Anemia represent an indications of, chronic renal failure, endocrine disease, joint disease, gastrointestinal disease, liver disease and so on , as well as, In patients with iron, B12 and Folate deficiency can cause anemia (2). On the other hand, polycythemia can lead to reducing O_2 transport capacity – for example Carboxyhemoglobin formation in chronic smokers- reduced O_2 release from hemoglobin, renal hypoxia, and Autonomous erythropoietin biosynthesis (3).

Anemia is defined as decreased in the oxygen carrying capacity of the blood due to a decreased RBC's count or Hb content or both below the normal range for edge and sex. This disease can lead to an increase in heart

rate and pulse pressure as a result of decreasing in blood viscosity and low in peripheral resistance, decreasing in O_2 supply to the tissue (hypoxia), vasodilatations from hypoxia and increasing in heart rate which lastly may lead to heart failure, and in hemolytic anemia there is increasing in formation of bilirobin which lead to jaundice in addition to clinical effects like headache blurring of vision and so on (1)(4).

On the other hand, polycythemia or erythrocytes is refers to an increase in the RBC's mass. At Hct above 50%, blood viscosity increases exponentially, and cardiac function and peripheral blood flow may be impaired. With a Hct above 60%, blood flow may by so compromised as to lead to tissue hypoxia (1)(4).

For that reason, it was needed to provide a new applicable technique to be personal use, easy, highly accuracy fast in getting result that will use for early detection. Also, using laser light and exploiting some of its highly sensitive characteristics like change in light speed, and mono chromaticity, represent a helpful techniques for that purpose.

Recently, clinical health laboratories are depending on determination of packed cell volume (PCV) method for detecting the presence or absence of anemia or polycythemia, that measured by centrifugation.

The accuracy of the results can be affected by using dirty or moist tubes, poor quality tube which are not of uniform bore, uneven seal, in complete packing due to insufficient force (low RPM, short centrifuge arms), errors related with trapped plasma that will be increased in patients with polycythemia (5).

Noninvasive monitoring techniques were used to detect Hb concentration *in vitro*, for example, Plethysmography Sensors, this method include using two detectors; one was electrical sensor designed to measure blood volume changes during the cardiac cycle and optical sensor for detection of dye concentration which is analogous to human Hb. the quantities were discussed as a possible index of *in vivo* hemoglobin concentration (6).

Doshi and Panditrao in 2013 described indirect method for Hb concentration determination using finger chip, that consist of upper shell contain LED with two different wavelengths (660 and 940nm)for detection of deoxygenated and oxygenated hemoglobin respectively, transimpedance amplifier-detector- was installed in the lower shell of the finger clip. Output signal voltage was measured also output waveform is observed on digital storage oscilloscope, the Hb concentration was determined by putting the finger between the finger chip of different subjects with different ages (7).

Ahmed *et. al.* explained a direct method for measuring Hb Concentration for men and women, using three different lasers' wavelengths – depending on absorption spectrum of hemoglobin- with different output power, and optical fiber as a sensor for the quantity of transmitted light that passed through the blood sample, they alleged that blood Hb concentration could be determined by plane polarized light (8), while the practical truth that had been sustained was the blood hemoglobin could not be able to rotate the incident plane polarized field.

However, they demonstrate the result that had been get were depended mainly on absorbance measurements to determine any changes in Hb concentration that absorb a certain wavelength of light.

Other articles like (9),(10)(11) were explained the same method of pulse oximetry (finger clip) in measuring Hb concentration with the same principal of working. In this work, a new suggested biosensor

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design was used to determine either the patient had anemia or polycythemia, by comparison between tested or control blood samples of healthy persons with normal PCV, according to the blood group control. The blank of biosensor is distilled water that used by calibration with polarizer to make the reading power 26.99 μW as W_o .The designation of biosensor used Beer-Lambert principle as following:

$Wx = Wo \exp-\alpha x$

Where; W_x is the power of light through the sample, W_o is the power of incident light from source, x is the path length of laser light equal to 1cm of Cuvette sample, α is the absorption coefficient of sample that it is different with different blood group and Hb concentration.

Material and Methods

Blood Sample:

Five replicates of different blood sample were taken from (Kut Bank of Blood) of different healthy persons, different blood groups, with convergent PCV values; in order to use as control.

(AL-Karamma Hospital) supported the project with 35 blood sample from patient of anemia, and 35 blood samples from patient with polycythemia, with same PCV for each group, and each sample were classified according to blood group.

The control blood samples and tested blood samples were diluted with distilled water. The diluted factor was 1:90. The donor persons are of age between 1863 years old.

Biosensor setup:

It consists of (figure 1):

1. Diode laser: wavelength 650 nm, output power through blank of distilled water 26.99 μW.
2. Polarizer: to calibrate the output power of laser beam.
3. Cuvette contain blood sample.
4. Photocell to convert optical signal in to electrical signal.
5. Power meter.

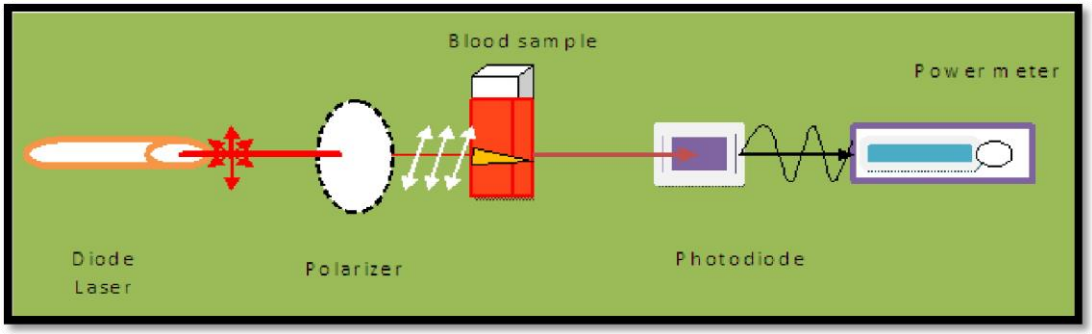

Figure 1: Biosensor arrangement

Results and Discussion

The results – appendix- were analyzed using SPSS program by comparing means between blood sample of normal PCV as a control, and blood sample of anemia and polycythemia.

In general, according to beer-Lambert law, the decreasing in Hb concentration – Anemia- leads to increasing in transmittance of laser beam through blood sample, and subsequently, the readings seems higher than control. This results as same as the results that reached by Ahmed, *et.al* (8). While in case of Polycythemia, the means of tested samples were seemed to be less than control; due to increasing absorption of high Hb concentration.

In case of anemia, the results show there were a significant increasing in transmitted light, between the control and tested sample of blood groups (O+, AB+, O+, and O-), while there were no significant difference in B+ samples. For polycythemia, the highly significant difference was seen in (A+, A-, AB-, and A-), significant difference in O+, and B+ show no difference with control.

Conclusion

B+ blood groups test, showed no significant increasing or decreasing in biosensor readings for anemia and polycythemia respectively, that made a hypothesis there were a correlation between Hb concentration and blood group, i.e that reading of blood group could interfere with increasing and decreasing of Hb concentration for certain groups.

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Appendix

Anemia Data										
A+	B+	AB+	O+	O-	A+ control	B+ Control	AB+ Control	O+ Control	O- Control	Factor
23.77	21.55	21.9	24.6	20.31	19.45	23.17	19.72	19.75	17.53	26.99
24.12	16.7	24.98	26.12	25.33	18.68	22.16	18.11	19.03	17.5	
24.8	22.33	23.63	24.44	26.4	18.59	21.9	17.62	17.89	17.13	
25.25	26.03	22.94	24.91	27.65	17.32	20.82	17.4	17.33	16.78	
25.22	25.5	23.75	24.92	26.53	17	19.52	15.08	17.15	16.22	
25.24	25.93	24.9	25.02							

25.38	22.24									
25.46	23.53									
25.3										
24.77										

Polycythemia Data												
A+	B+	O+	A-	AB-	O-	Control A+	Control B+	Control O+	Control A-	Control AB-	Control O-	Factor
21.56	22.33	19.57	19.73	22.6	22.97	19.45	23.17	19.75	17.32	19.53	17.53	26.99
22.82	22.35	23.21	19.25	21.44	21.45	18.68	22.16	19.03	15.77	19.92	17.5	
22.6	22.89	23.22	18.67	22.37	21.75	18.59	21.9	17.89	15.58	18.61	17.13	
22.96	22.5	22.76	19.03	21.98	21.53	17.32	20.82	17.33	14.25	18.31	16.78	
22.13	23.05	23.75	19.83	20.66	22.76	17	19.52	17.15	12.65	17.88	16.22	
		22.97										
		22.1										
		21.79										
		21.49										
		21.93										

Paired Samples Test (Anemia)				
	Paired Differences	t	df	

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		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				Sig. (2tailed)
					Lower	Upper			
Pair 1	A+ - control A+	6.42400	1.65337	.73941	4.37107	8.47693	8.688	4	.001
Pair 2	B+ - control B+	.90800	4.78025	2.13779	-5.02746-	6.84346	.425	4	.693
Pair 3	AB+ - control AB+	5.85400	2.37610	1.06262	2.90369	8.80431	5.509	4	.005
Pair 4	O+ - control O+	6.76800	1.17189	.52408	5.31291	8.22309	12.914	4	.000
Pair 5	O- - control O-	8.21200	3.24956	1.45325	4.17714	12.24686	5.651	4	.005

Paired Samples Test (Polycythemia)									
		Paired Differences					t	df	Sig. (2tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	A+ - control A+	4.20600	1.35519	.60606	2.52331	5.88869	6.940	4	.002
Pair 2	B+ - control B+	1.11000	1.64656	.73636	-.93447-	3.15447	1.507	4	.206
Pair 3	O+ - control O+	4.27200	2.63195	1.17704	1.00400	7.54000	3.629	4	.022

Pair 4	A- - control A-	4.18800	1.88220	.84174	1.85094	6.52506	4.975	4	.008
Pair 5	AB- - control AB-	2.96000	.90308	.40387	1.83868	4.08132	7.329	4	.002
Pair 6	O- - control O-	5.06000	.98191	.43912	3.84080	6.27920	11.523	4	.000