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Diurnal, Postural and Postprandial Variations of Hematocrit

GEORGE A. MAYER, M.D.,* *Kingston, Ont.*

ABSTRACT

The microhematocrit (HCT) values of 59 subjects increased significantly in the sitting position and after moderate exercise, in comparison with the values obtained during recumbency. The consumption of an 800-calorie meal decreased the HCT and this effect lasted for six hours. In order to obtain comparable results blood for HCT should be taken in a "standard basal condition" in the morning hours, in the fasting state or after a light breakfast, and the patient should sit for at least 30 minutes before the blood specimen is taken.

SOMMAIRE

Les valeurs de la microhématocritie (HCT) de 59 sujets ont augmenté sensiblement en position assise et après un exercise modéré, par rapport aux chiffres fournis alors que les sujets étaient couchés. La consommation d'un repas de 800 calories a diminué la valeur de l'HCT et cet effet a persisté pendant six heures. En vue d'obtenir des résultats comparables, le sang destiné à l'HCT doit être prélevé "dans des conditions de base standards", aux heures du matin, à jeûn ou après un léger petit déjeuner et le malade devrait être assis pendant au moins 30 minutes avant de prélever le spécimen de sang.

THE high reproducibility and accuracy of hematocrit determinations have made this test very useful and popular in routine laboratory studies. The individual hematocrit values of healthy subjects and of patients without obvious disorders of plasma or red cell volume are considered in recent textbooks as constant during a period of one or several days. A few publications in the past, however, demonstrated some diurnal, postprandial and postural changes in red blood cell count, hemoglobin and hematocrit values.[1-6] Since the stability or fluctuation of hematocrit value, independent of any morbid condition in healthy or sick individuals, is of practical importance, we investigated this problem in 59 volunteers.

MATERIAL

This study was carried out on 31 healthy (H) hospital employees (six females and 25 males) and on 28 patients (eight females and 20 males) with chronic coronary heart disease (CHD). The healthy subjects performed light hospital duties involving moderate physical activity. Most of the patients were hospitalized in the Special Investigation Unit for reassessment of their condition. All were ambulatory, without acute distress, heart failure or hypertension, and did not take drugs except for nitroglycerin occasionally; 22 of the patients were on long-term anticoagulant therapy during this study. During the testing periods they did not have anginal episodes and did not take nitroglycerin. Several volunteers participated in more than one experiment described in this study.

From the Department of Medicine, Queen's University, and the Special Investigation Unit, Kingston General Hospital, Kingston, Ontario.
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*Research Associate, Ontario Heart Foundation.

Unless stated otherwise the volunteers walked to the laboratory and were seated for at least 30 minutes before tests. The withdrawal of blood was carried out with the subject in sitting position, the arm being approximately at the level of the heart. For tests during recumbency the blood was taken from volunteers resting in their beds.

METHOD

Ten ml. of blood was drawn through a 19-gauge needle from the antecubital vein in a dry syringe after application of a tourniquet for no more than 15 seconds and transferred to a Vacutainer tube containing 10 units of dry heparin per ml. of blood. The tube was placed in a slowly rotating mixer for 10 to 20 minutes to prevent sedimentation of the cellular elements. Duplicate microhematocrit determinations (HCT) were performed immediately after this mixing period in a high-speed Drummond centrifuge, according to the technique of Strumia, Sample and Hart.[7] The data presented in Tables I to VI represent the mean and standard deviation (SD) of the individual readings.

RESULTS

1. The reproducibility of the technique was evaluated by 20 tests made by five technicians upon the same blood sample. The mean value was 45.97%, SD ± .403, SE ± 0.09. (This last figure is the standard error of the technique.)

2. Diurnal variations were tested in 10 volunteers during their normal daily activities and in six subjects at complete bed rest. All these subjects were fasting throughout the experiment. Blood samples were taken at 9 a.m., at 12 noon and at 5

TABLE I.—VARIATIONS OF HEMATOCRIT: DIURNAL VARIATIONS IN FASTING STATE

Posture during experiment	Subjects			9 a.m.	12 noon	5 p.m.
	No.	Sex	Health			
Bed rest*.....	6	3 F 3 M	6 CHD	40.3 ±4.5	39.0 ±5.1	39.0 ±5.1
Ambulatory*.....	10	10 M	6 H 4 CHD	45.9 ±2.1	45.2 ±2.6	45.0 ±2.7

*No significant difference between means.

p.m. The data in Table I show a slight, statistically non-significant decrease of HCT at noon as compared with the morning samples. From noon until 5 p.m. no change was observed. In a group of 10 volunteers, from whom blood was taken with the subject in the sitting position, we determined HCT before and after a light breakfast consisting of a cup of coffee with sugar, two slices of toast with 10 grams of butter, and one fried egg (Table II).

TABLE II.—VARIATIONS OF HEMATOCRIT: EFFECT OF BREAKFAST

Subjects			Before breakfast 8 a.m.	60 to 120 min. after breakfast 9 to 10 a.m.
No.	Sex	Health		
10	3 F 7 M	10 H	43.0 ± 2.9	42.9 ± 2.6

No significant difference between means.

No change was observed 60 to 120 minutes after breakfast. This experiment also showed that the withdrawal of the first 10 ml. of blood did not affect the subsequent results. The mean HCT of 10 ambulatory subjects determined on three days of the same week after a light breakfast showed no change (Table III). The individual daily variations were within the limits of technical error of the method.

TABLE III.—DAILY VARIATIONS OF HEMATOCRIT ON THREE DAYS OF THE SAME WEEK. BLOOD TAKEN AT 9 A.M. AFTER LIGHT BREAKFAST

Subjects			Day 1	Day 2	Day 3
No.	Sex	Health			
10	4 F 6 M	10 H	43.3 ±2.9	43.2 ±2.7	43.3 ±2.9

No significant difference between means.

3. The effect of posture was investigated by comparing the hematocrit readings of sitting or walking subjects with their own values obtained at bed rest (Table IV). Blood was taken, with the subject in recumbent position, from 40 volunteers in the morning hours after an overnight complete bed rest. Thereafter they were seated in an arm chair for 30 to 60 minutes and another hematocrit determination was performed. Subsequently they were instructed to walk in the corridor or ward for 30 to 60 minutes and another HCT was performed immediately after this moderate exercise.

TABLE IV.—VARIATIONS OF HEMATOCRIT: EFFECT OF SITTING AND WALKING

Subjects			After overnight bed rest* 9 a.m.	After sitting for 30 to 60 minutes 10 a.m.	Immediately after moderate walking for 30 to 60 minutes 11 a.m.
No.	Sex	Health			
40	10 F 30 M	14 H 26 CHD	42.5 ± 3.9	44.1 ± 3.9	45.5 ± 3.8

*Blood taken in recumbent position.
Analysis of variance F = 5.89, n_1 = 2, n_2 = 117. Critical value for F at 1% level of significance = 4.82.

The hematocrit was significantly higher after sitting than at bed rest and a further increase occurred after walking. We measured the HCT values of 12 volunteers in the recumbent position after complete bed rest and two hours later, immediately after 60 to 90 minutes of moderate walking. Thereafter they returned to their beds and remained in the recumbent position for 60 to 90 minutes. At the end of this period HCT was again determined. Table V shows that there was an increase of HCT after walking as compared with the recumbent values.

TABLE V.—HEMATOCRIT IN RECUMBENT POSITION AND AFTER WALKING

Subjects			After overnight bed rest* 8 a.m.	Immediately after walking for 60 to 90 minutes 10 a.m.	After bed rest for 60 to 90 minutes* 11:30 a.m.
No.	Sex	Health			
12	9 M 3 F	5 H 7 CHD	42.5 ± 3.8	44.8 ± 3.6	41.4 ± 3.2

*Blood taken in recumbent position.
Analysis of variance: F = 2.74, n_1 = 2, n_2 = 33. Critical value for F at 5% level of significance = 3.30.

4. The effect of food intake was measured in 27 ambulatory subjects (four females and 23 males, 23 healthy persons and four patients with chronic coronary heart disease). The meal was served at 12:15 p.m. and consisted of 800 calories in the form of potato, bread and various proteins such as broiled steak, or chicken, salmon, eggs, or dairy products. The total calorie intake was meticulously maintained; however, the composition of meals changed slightly according to the ingredients served. The first blood sample was taken between 11:30 and 11:45 a.m. From each individual one postprandial sample was taken either at 30 min. or one, two, four or six hours after the meal. The data in Table VI show that there was a significant postprandial decrease of HCT. The changes are of borderline significance 30 minutes and one hour

TABLE VI.—VARIATIONS OF HEMATOCRIT: EFFECT OF FOOD INTAKE IN AMBULATORY SUBJECTS

Number of test meals	Time of test after meal	Before meal	After meal	t	p
18	30 min.	46.9 ±2.5	45.5 ±2.3	1.75	0.05
23	1 hr.	45.7 ±2.9	44.7 ±2.7	1.21	0.1
54	2 hrs.	46.0 ±2.4	44.5 ±2.6	2.95	0.005
28	4 hrs.	45.8 ±2.3	44.2 ±2.2	2.66	0.01
15	6 hrs.	45.7 ±2.1	45.1 ±2.2	0.76	0.5

after a meal and were not significant six hours after a meal. No particular difference was observed amongst the HCT values obtained after meals consisting of different protein ingredients.

DISCUSSION

Awareness of the fact of variation in HCT values in an individual, independent of disease, is important for clinicians in order that they may be able to compare the results of this test in groups of healthy persons and of patients suffering from various diseases, and to evaluate improvement or deterioration in hematological disorders. The possibility of diurnal, postural and postprandial changes of HCT is not mentioned in recent textbooks and was not considered in many evaluations of HCT in various diseases.[8] The author observed several times an "inexplicable" 5% to 10% decrease of HCT in a matter of hours, when the patient walked to the laboratory in the morning for the first test and it was re-checked later in the afternoon at bed rest and after a meal. A similar observation was made when a preoperative HCT performed on an ambulatory patient was compared with a postoperative value obtained from the patient in the recumbent position. Not infrequently such a rapid decrease of HCT suggested the possibility of hemorrhage.

Our study demonstrates that HCT values, measured by a highly reproducible technique, show significant variations in individuals, independent of any disease. In our small groups of fasting volunteers at bed rest and of ambulatory subjects we observed a slight decrease of HCT in most of the subjects from 9 a.m. to 12 noon and no change thereafter (Table I). The change is not significant statistically but in a larger group it may be so. We can not therefore deny or confirm the results observed by Renbourn[5] and Cranston and Brown,[6] who reported a diurnal decrease of HCT from the morning to late evening. According to our investigations a light breakfast does not affect the readings (Table II) and the HCT does not change from day to day during one week of observation in ambulatory subjects if blood is taken early in the morning (Table III). A change of posture from recumbent to sitting position increases the HCT significantly, and moderate walking produces a further increase (Table IV). The comparison of post-exercise HCT with recumbent values demonstrates an increase of HCT after moderate walking (Table V). We did not perform serial testing to determine how rapidly the HCT would increase or decrease after a change of posture or after walking, but our preliminary observations indicated that after 30 minutes following the change of posture, the HCT did not vary any more. Thompson, Thompson and Dailey[1] demonstrated, as we did, an increase of HCT in the erect position which reached its maximum in 30 minutes. Our post-exercise readings confirm the report by Branwood,[4] who observed a post-exercise increase of hemoglobin and red blood cell count.

The consumption of an 800-calorie meal produces a significant decrease of HCT, as reported by Branwood[4] for hemoglobin. The changes at 30 minutes and one hour after meals are of borderline significance, but the small number of tests in these two groups may explain this observation. After six hours this postprandial fall of HCT disappears. The varying nature of proteins in the meals did not affect the results.

Our investigations show that the HCT is not stable during the day and is significantly affected by body posture and consumption of food. To provide comparable readings, healthy subjects or patients with various diseases should be in a "standard basal condition" at the time of the test. Blood should be taken in the morning hours, in a fasting state or after a light breakfast, and the patients should sit for at least 30 minutes before the withdrawal of blood. If these rules cannot be followed, the deviation should be noted and taken into consideration in the evaluation of the results.

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PAGES OUT OF THE PAST: FROM THE JOURNAL OF FIFTY YEARS AGO

A POLICY OF WISDOM

The work of the Montreal General Hospital increases steadily and, since the outbreak of the war, the authorities have been obliged to refuse admission to many applicants. At one time there were as many as 407 patients in the hospital, and in the outdoor department 512 were treated in one day. The policy of the Medical Board has always been to encourage the younger men in the profession to become connected with the hospital. The wisdom of such a policy is evident: a large number of those who were on the hospital staff are now on active service but their places have been taken by others already connected with the institution and the work of the hospital has been continued along established lines without confusion.—News, *Canad. Med. Ass. J.*, 5: 908, 1915.