Studies of Megakaryocyte Glycogen.

I. A Semiquantitative Method of Measurement: Effect of Phlebotomies in Young Adults

By HARRY W. DANIELL

SEVERAL DESCRIPTIONS of the histochemically demonstrable glycogen in megakaryocytes have appeared in the European literature. Descriptions in the American literature have been less detailed, perhaps because they were included in histochemical surveys of all blood and bone marrow-formed elements. The results of several histochemical methods of demonstrating glycogen have been reported and compared, but most authors have preferred to use the Periodic Acid-Schiff method of Hotchkiss for their investigations.

Few studies have included examinations of pathologic material. Gibb and Stowell reported a "possible" increase in megakaryocyte glycogen in polycythemia vera and noted no other abnormal increases or decreases in their series of marrow specimens from patients representing many hematologic disorders. Wachstein studied megakaryocytes in a smaller number of aspirations and reported no abnormalities in any of the specimens examined. Other investigators have confined their studies to normal human bone marrow and to material from animals.

This paper extends previous observations on the distribution of megakaryocyte glycogen in man, describes a semiquantitative technic for determining the relative amount of megakaryocyte glycogen in aspirated bone marrow, and reports observations on a series of aspirations from healthy young adults.

METHODS

Small amounts of bone marrow were aspirated by the usual technic from an iliac crest, the sternum or a vertebral spine, smeared on clean glass slides and dried in air. Smears were then stained by the Periodic Acid-Schiff (PAS) technic as described by Hotchkiss and counterstained with Harris hematoxylin. The technic which has been used by most investigators was modified by substituting air-drying for the final alcohol-xylene dehydration. This modification resulted in improved definition of the cytoplasmic detail.

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*See footnote, facing page.
STUDIES OF MEGAKARYOCYTE GLYCOGEN. I.

A few slides previously stained by the Wright-Giemsa technic and stored for periods of time up to three years were treated by the Hotchkiss technic, counterstained with hematoxylin and examined. The periodic acid solution was found to remove the Wright-Giemsa coloration. Megakaryocyte glycogen demonstrated by the subsequent completion of the Hotchkiss technic is indistinguishable (in terms of cellular distribution or staining intensity) from that demonstrated in previously unstained smears from the same aspiration. This confirms the observations of Storti, who utilized smears previously stained with Wright-Giemsa in some of his studies.

RESULTS

1. Megakaryocytes Stained by the Hotchkiss Technic

The biochemistry of the Hotchkiss technic has been reviewed in detail by others.1,10,12,14 Pearse14 states that molecules giving PAS-positive reactions include glycogens, mucopolysaccharides, mucoproteins and glycoproteins, glycolipids and a few unsaturated lipids and phospholipids. By incubating with saliva prior to execution of the procedure, glycogen (unlike the other molecules) is rendered unstainable. Comparison of cells in untreated and saliva-treated smears, therefore, identifies structures which are glycogen.

Megakaryocytic nuclei are not stained by the PAS technic. In contrast, extranuclear structures stain in four characteristic patterns, several of which may exist in combination. Two of these patterns occur within the megakaryocyte cytoplasm, while the other two are seen at the cell periphery. The latter apparently represent platelet formation (or platelet juxtaposition) and the viscoid membrane of Schwartz.

(a) Glycogen inclusion bodies: The most prominent structures seen in many megakaryocytes stained by the Hotchkiss technic are discrete masses of strongly staining material which vary widely in number and distribution from

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*The technic utilized in this study was as follows:

1. Absolute ethanol 5 min. 10. Sulfite bath 5 min. (after Hotchkiss)
2. 1% collodion 5 min. 11. Tap water wash
3. Periodic acid 5 min. (after Hotchkiss) 12. Harris hematoxylin 1 min.
4. 70% ethanol 5 min. (after Hotchkiss) 13. Tap water wash
5. Reducing bath 5 min. 14. 2% acetic acid 5 min.
6. 70% ethanol 5 min. 15. Tap water wash
7. Schiff's leucofuchsin 45 min. (after Hotchkiss) 16. 0.1 N HCO₃ sol. 5 min.
8. Sulfite bath 5 min. (after Hotchkiss) 17. Tap water
9. Sulfite bath 5 min. (after Hotchkiss) 18. Air dry

Subsequently, it has been found that the following simplified technic gives satisfactory results:

1. 95% ethanol 5 min. 6. Tap water rinse
3. 0.5% periodic acid 5 min. 8. Tap water rinse
in distilled water 9. Ammonia water 1 min.
4. Distilled water rinse 10. Tap water rinse
5. Schiff's leucofuchsin 15 min. 11. Air dry
Figs. 1–9. See legend, facing page.
cell to cell (figs. 5–9). Many megakaryocytes have very small inclusions localized adjacent to the nuclear membrane, paralleling the nuclear contour (figs. 5, 6), while other cells exhibit relatively large masses of stained material at this site (fig. 7). Some cells contain varying numbers of large or small discrete homogenous inclusions distributed throughout the cytoplasm (figs. 8, 9), while in still others, the cytoplasm contains several groups of fragments with less distinct borders (figs. 7, 9). The amount of cytoplasm occupied by these inclusion bodies varies considerably. In some cells they are barely discernible (fig. 5), while in others they appear to occupy as much as 30 per cent of the cytoplasmic volume (fig. 8). Descriptions of these inclusions have previously been published. All previous investigators agree that they are removed completely by saliva pretreatment and are, therefore, composed of glycogen. This observation was confirmed in the present work, as was the observation of Wachstein who reported that alcohol fixation prior to saliva treatment augmented the action of saliva. The relative prominence of these glycogen bodies is the only characteristic which is graded in the scoring system to be described.

A relationship between megakaryocyte maturity and the presence of these

Legend, figures 1–9

Fig. 1.—Grade 0. Adult Megakaryocyte: The fine, diffuse granular background is evident without glycogen inclusions, platelet formation or viscid membrane being present. Note intense stain in polymorphonuclear neutrophils.

Fig. 2.—Grade 0. Adult Megakaryocyte: Very lightly stained granular cytoplasm without glycogen inclusions, platelet formation or viscid membrane. Note intensity of Periodic Acid-Schiff stain in polymorphonuclear neutrophils and obviously mature megakaryocyte nucleus.

Fig. 3.—Grade 0. Promegakaryocyte: Viscid membrane containing many glycogen globules surrounds megakaryocyte. The granular megakaryocyte cytoplasm has a diffuse PAS-positive staining, but no evidence of glycogen inclusions.

Fig. 4.—Grade 0. Promegakaryocyte: Glycogen globules in viscid membrane are larger and less uniform in size than in Figure 3 and many of them are located in small "pseudo-pods," probably formed by shearing in the process of making the bone marrow smear. A small group of platelets are seen at 4 o'clock. The nucleus occupies a large part of the cell, but nonglycogen-containing cytoplasm can be seen.

Fig. 5.—Grade 1. Intermediate form: One small inclusion of glycogen can be seen adjacent to the nucleus at 3 o'clock. No evidence of viscid membrane or platelet formation. Note intense staining of polymorphonuclear leukocyte in spite of faintly staining megakaryocyte cytoplasm.

Fig. 6.—Grade 1. Adult Megakaryocyte: Many glycogen inclusions can be seen almost "ringing" the multilobed nucleus. No other glycogen inclusions are present, nor is there evidence of platelet or pseudoplatelet structure. The strongly PAS-positive stained, large, circular structures above the megakaryocyte are starch granules.

Fig. 7.—Grade 2. Adult Megakaryocyte: Many glycogen inclusions seen at nuclear membrane near the rim of the cytoplasm and in body of cytoplasm. Perhaps platelet formation is evident at 3 o'clock.

Fig. 8.—Grade 4. Adult Megakaryocyte: Very large numbers of intensely staining inclusions throughout cytoplasm with some large inclusions at the periphery of cell. This grade is very rarely seen in persons without evidence of intense erythropoietic stimulation in the recent past or at present. Cell from a patient with polycythemia vera, untreated.

Fig. 9.—Grades 2, 3, 3. Adult Megakaryocytes: Cells from a patient with polycythemia vera, untreated. Note intense PAS-staining in polymorphonuclear cells as well.
glycogen inclusion bodies appears to exist. Although classification of megakaryocytes into the accepted cell types is dependent upon morphologic characteristics demonstrated by the more commonly used staining technics (i.e., cytoplasmic granulation), the maturity of most cells can be accurately determined by other criteria which are present after application of the Hotchkiss technic (cell size, nuclear chromatin configuration, nuclear lobulation, pseudo-platelet formation, etc.). Glycogen inclusions were not seen in megakaryoblasts or early promegakaryocytes although older promegakaryocytes may contain small amounts of glycogen. Intermediate forms and adult megakaryocytes often contain glycogen, although in most aspirations adult megakaryocytes without glycogen were observed (fig. 2). This relationship between the presence of glycogen inclusions and cell maturation confirms the observation of Stort\textsuperscript{19} who reported that glycogen inclusions are demonstrable only in those cells which contain granulations when stained by the Wright-Giemsa technic.

(b) **Diffuse cytoplasmic coloration:** The megakaryocyte cytoplasm stained by the Hotchkiss technic characteristically presents a fine, diffusely distributed coloration throughout the cytoplasm. Often it is more intense in the central or perinuclear portion of the cell than at its periphery (figs. 1–9). It appears like a pink, sandy background on which the characteristic glycogen inclusions, if present, are superimposed. This diffuse coloration is present in every cell although its intensity varies greatly from cell to cell within the same smear, as well as from aspiration to aspiration. In some cells it is barely discernible (fig. 2) while very rarely it will be intense enough to nearly obscure the glycogen inclusions (figs. 8, 9). All authors who have studied megakaryocytes utilizing the Hotchkiss technic have reported the presence of this diffuse granulation. They agree that it is unaffected by saliva pretreatment and that it is not glycogen. The present studies confirm these observations. This non-glycogen material is not considered in the semiquantitative evaluation of megakaryocyte glycogen.

(c) **Extracellular glycogen granules:** The third pattern characteristic of Hotchkiss-stained megakaryocytes is that presumed to represent platelets or platelet formation. It consists of groups of many small granules of varying size located at or outside the periphery of the cell (figs. 4, 7, 8). These granules are removed by saliva pretreatment and are similar in shape, size and coloration to the glycogen granules in platelets observed apart from the megakaryocytes in the bone marrow smears (fig. 4) or in the smears of the peripheral blood. Only rarely do aggregations of these small granules lie within the cytoplasmic borders of the cell.

(d) **Glycogen granules in the viscid membrane of Schwartz:** The fourth characteristic localization of megakaryocyte glycogen is its presence in the viscid membrane surrounding promegakaryocytes and some intermediate forms (figs. 3, 4). Usually this glycogen is distributed as small to medium sized globules located in “buds” of nongranular material extending from the granular megakaryocyte cytoplasm. Occasionally the amount of viscid material is so prominent as to take the form of an envelope of varying thickness completely enclosing the rest of the megakaryocyte. The agranular viscid
material is easily differentiated from the granular megakaryocyte cytoplasm and is sharply demarcated from it. The glycogen particles in this viscoid material are globular in contrast to the irregular shape of the glycogen inclusions in the granular megakaryocyte cytoplasm. In addition, these globules are often uniform in size, in contrast to the wide variations in size and shape of the glycogen inclusions. No difficulty is encountered in differentiating the glycogen in these pseudopods from that within the true cytoplasm of the megakaryocytes. Storti¹⁹ has reported glycogen inclusions located in cytoplasmic buds as being “distinct from typical figures of platelet formation.” The presence or absence of these pseudopods and the presence or absence of their glycogen globules is apparently unrelated to any bone marrow pathology, and they are not included in any way in the scoring of megakaryocyte glycogen.

2. Megakaryocyte Glycogen Score (MGS)

Previous investigators have not attempted to quantify the amounts of glycogen observed in megakaryocytes. Preliminary observations on pathologic bone marrow specimens³ demonstrated the necessity of developing objective criteria by which the megakaryocyte glycogen of individual cells could be compared and by which the glycogen present in cells of one aspirate could be compared with those of another. In order to meet this need, a method for evaluating the glycogen in megakaryocytes of a smear was developed and subjected to a number of tests aimed at delineating its reliability. This evaluation is termed the Megakaryocyte Glycogen Score (MGS).

Each slide prepared by the modified Hotchkiss technic was examined systematically under low-power for megakaryocytes. All megakaryocytes found were examined under oil immersion and scored 0, 1, 2, 3 or 4 according to the following criteria:

Grade 0 (figs. 1–4): No cytoplasmic glycogen inclusion bodies. These cells may have glycogen in pseudopods, apparent platelet formation and intense diffuse cytoplasmic staining or any of these in combination.

Grade 1 (figs. 5, 6): A minimal amount of megakaryocyte glycogen. This is usually located just outside the nuclear membrane. Cells containing glycogen bodies in their more peripheral cytoplasm will usually have at least several such bodies and require a score of more than one. The majority of glycogen-containing megakaryocytes in normal marrows are Grade 1.

Grade 2 (figs. 7, 9): Substantial amounts of glycogen located either near the nuclear membrane or scattered diffusely throughout the entire megakaryocyte cytoplasm. Some Grade 2 cell can be found in most normal marrows.

Grade 3 (fig. 9): Much larger amounts of glycogen distributed throughout the megakaryocyte cytoplasm and occasionally obscuring portions of the nucleus.

Grade 4 (fig. 8): Very large amounts of glycogen occupying perhaps 20 to 30 per cent of the megakaryocyte cytoplasm. These cells are very rarely seen in normal bone marrow aspirations.

Examination of the smear was completed in such a way that areas tending to have increased numbers of megakaryocytes (the edges, the ends and
fragments of marrow tissue distributed in the smear) were given representative, but not excessive, attention. The scores of 50 to 300 cells were recorded and results expressed in terms of 100 cells as the Megakaryocyte Glycogen Score (MGS).

The amount of material studied in order to complete the MGS varied greatly from aspiration to aspiration. Specimens in which megakaryocytes were scant, or in which the aspiration material was diluted with much peripheral blood, required studying as many as four to five slides completely. Some smears, particularly those from patients with polycythemia vera and idiopathic thrombocytopenic purpura, contained large numbers of megakaryocytes. It was found that the minimum slide area giving satisfactory results in these conditions was a strip traversing the length of the slide and at least a low-power field in width. Such a field may contain several hundred megakaryocytes.

The reliability of the MGS was tested by comparing independent observations on the same smear by two observers and by comparing independent observations by the same investigator separated by a two-month time interval. Results of these tests are recorded in table 1. Each series of observations was made without knowledge of either the source of the aspiration material or the megakaryocyte glycogen score recorded on previous occasions. The MGS is demonstrated to have a high degree of reproducibility. Minor variations between successive scores on the same smear are explained on a statistical basis.

3. Normal Values of MGS and Relation to Repeated Blood Loss

Twenty bone marrow aspirations were completed on 14 healthy young adult volunteers. Duplicate smears from each aspiration were stained, one with the Hotchkiss technic and one with Wright-Giemsa. Differential counts after Wright-Giemsa were well within normal limits. Peripheral blood studies at the time of aspiration included hematocrit, rbc, reticulocyte counts, wbc with differentials and platelet counts. In all subjects these determinations were within the normal limits. These data are recorded in table 2.

Evaluations of the hematologic histories of these "normal" subjects demonstrated an apparent relationship between their overt blood loss in recent years and their MGS. These data are included in table 2 and summarized in figure 10. Subjects with repeated episodes of acute blood loss over the five-year period prior to aspiration had greater amounts of megakaryocyte glycogen than did those without such blood loss. All subjects with less than three liters of overt blood loss in the five-year period had MGS values between 20 and 80. A similar range of values has been observed in hospital patients who had diseases not related to the hematopoietic system. Preliminary observations indicate little change in the MGS from time to time in the same healthy person (table 3) unless he is subject to acute blood loss (fig. 11).

4. Effects of Acute Blood Loss

Preliminary studies have been made on changes in the MGS following acute blood loss. One subject had serial aspirations before and after a 500
TABLE 1.—Comparison of Independent Determinations of the Megakaryocyte Glycogen Score (MGS)

<table>
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<th>III Observer A</th>
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I-II SD 6.5
II-III SD 6.0
I-III SD 5.9

TABLE 2.—Megakaryocyte Glycogen Scores in Healthy Young Adults

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<tr>
<th>Subject</th>
<th>Age &amp; Sex</th>
<th>Hemoglobin Gm.%</th>
<th>Leukocytes per mm.³</th>
<th>Platelets per mm.³</th>
<th>Reticulocytes per 100 rbc</th>
<th>Estimated Blood loss (in cc.) Past 5 years</th>
<th>MGS</th>
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Table 3.—Megakaryocyte Glycogen Scores on Successive Bone Marrow Aspirations from Healthy, Young Adults

<table>
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<th>Subject</th>
<th>Age &amp; Sex</th>
<th>First Aspiration</th>
<th>Second Aspiration 9-11 weeks later</th>
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<td>28 M</td>
<td>60, 52, 52*</td>
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<td>J.W.</td>
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<td>B.B.</td>
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*Separate aspirations at weekly intervals.

Fig. 10.—Estimated blood loss of "control" medical student subjects plotted against their MGS values. A correlation between repeated episodes of acute blood loss and increases in the MGS is apparent. All subjects with less than 3000 cc. overt blood loss over this 5-year period had MGS values between 20 and 80, a range similar to that of hospital patients with normal erythropoietic rates.
Fig. 11.—Alteration in the MGS in response to acute blood loss. Repeated aspirations prior to phlebotomy were within the normal range. Phlebotomy was followed in 1 hour by a probable decrease in the MGS (accompanied by a transient thrombocytosis); in four hours by a significant increase in the MGS to levels considerably above the "normal" range; in 2 days by a continued elevation; and in 25 days by a drop toward the normal range, once more. Elevation in the MGS preceded changes in the reticulocyte count and persisted for a considerable length of time after the reticulocyte count and hematocrit had returned to normal, prephlebotomy values.

sisted long after it had disappeared. A temporary decrease in MGS occurred in the presence of a temporary increase in peripheral blood platelets.

DISCUSSION

The introduction of histochemical technics into the field of hematology was soon followed by the demonstration of histochemical differences in blood cells from patients with a number of hematologic disorders. These observations have led investigators to attempt to develop methods by which their histochemical observations could be quantitated, thereby facilitating comparison of separate observations on a number of specimens. Most of these methods have consisted of scoring (from 0 to 4) the intensity with which each cell of the type under study exhibits the end product of the histochemical reaction being used.1,9,11

The methods have added to our knowledge of cellular physiology and in some respects appear to be helpful in diagnosis.9,11 Investigators utilizing these scoring technics have recognized that they leave much to be desired as semiquantitative measurements. The scoring of cells is subjective and includes an undesirable amount of human error. Technical details are often
exacting, and even the most carefully controlled procedures sometimes yield varying degrees of staining intensity.

The technic described for comparison of the megakaryocyte glycogen from a series of aspirations has overcome several of these disadvantages. The most evident of these is the utilization of more objective criteria for the grading. No cells are ±. Megakaryocytes either reveal glycogen inclusion bodies or they do not. The absence of the dependence on the intensity of the staining reaction is also advantageous. Glycogen inclusions which have been stained faintly because of technical difficulties receive the same weight in the scoring method as inclusions which have been stained well by the Hotchkiss technic. The reproducibility of the MGS may be attributed in large part to these factors.

Demonstration of a relationship between increased megakaryocyte glycogen and previous episodes of acute blood loss from which the subject had completely recovered by other hematologic criteria is of interest. The demonstration of increased megakaryocyte glycogen in the presence of increased erythropoiesis and decreased megakaryocyte glycogen when erythropoiesis is diminished has stimulated a detailed discussion of the nature of the relationship between the two factors. The hypothesis formulated in the course of this discussion states that glycogen is stored in megakaryocytes as a potential energy source to be utilized in the work of platelet production and that the need for this energy store is increased in the presence of increased erythropoiesis because of lowered marrow oxygen tension.

Localization of glycogen at the nuclear-cytoplasmic interface again points to that site as an important one in cellular metabolism. Forbes and Heinz have noted a similar arrangement in endometrial tissue, where this site is also prominent in the synthesis of cytoplasmic protein. Glycogen might reasonably be involved in supplying energy for the protein synthesis of platelet production.

Whether active menses are accompanied by fluctuations in megakaryocyte glycogen is not known. Information available is limited to the two women included in this “normal” series and to those in our studies in hospital patients. Data from the latter group suggest that the MGS is higher in menstruating patients with iron-deficiency anemia than in nonmenstruating patients with the same degree of iron deficiency. Menses have been included in the evaluation of our data at an estimated 30 cc. per menstrual period, or 2000 cc. for the five-year period.

A close parallel between erythropoiesis and the MGS has been demonstrated in a wide variety of conditions. The blood loss of 30–120 cc. associated with a normal menstrual period must stimulate erythropoiesis, but whether the resulting minor alteration in marrow metabolism is reflected in an altered MGS is unknown. The profound effect of a single 500 cc. phlebotomy on megakaryocyte glycogen indicates the sensitivity with which the MGS can change in response to blood loss. Monthly endocrine changes, known to alter some aspects of carbohydrate metabolism, might reasonably affect the megakaryocyte glycogen.

Young megakaryocytic forms (usually promegakaryocytes) stained with
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Wright-Giemsa or a similar technic often reveal a nongranular viscid material outside the bounds of the granular megakaryocyte cytoplasm. Its prominence in the promegakaryocytes of smeared bone marrow aspirate varies from a few, small pseudopod-like structures (which some authors have interpreted as atypical platelet formation\textsuperscript{2,5,15,20} or pseudoplatelet formation\textsuperscript{6,13,17}) to a viscid envelope entirely enclosing the cell. It has been described in some detail by Schwartz\textsuperscript{17} and its appearance in a number of pathologic situations, particularly idiopathic thrombocytopenic purpura, has been assigned some importance by a number of investigators.\textsuperscript{2,5,6,13,15} Schwartz\textsuperscript{17,18} feels that it is a cellular component probably not directly related to platelet formation, which gradually disappears with maturation of the cell being absent in all adult megakaryocytes. He feels that the pseudopod or pseudo-platelet formation described by other authors represents distortion of this viscid envelope due to the shearing forces inherent in the methods used for making smears of bone marrow aspirate. These studies conform to his hypothesis.

Air-drying after hematoxylin counterstain results in considerable improvement in cellular detail in smears of bone marrow aspirate when compared with the alcohol-xylene dehydration used by previous investigators. Reasons for this difference are unknown. Confirmation of Storti's observation that previous application of a Wright-Giemsa stain does not interfere with subsequent study using the PAS technic, and the observation that long periods of storage after Wright-Giemsa staining does not impair study by the PAS technic, should facilitate studies of megakaryocyte glycogen in those institutions with "bone marrow libraries."

SUMMARY

1. The distribution of glycogen and nonglycogen structures in megakaryocytes as demonstrated by the Hotchkiss technic is described.

2. A semiquantitative method for estimating the relative amounts of megakaryocyte glycogen in a bone marrow aspiration has been developed and is described. The result is expressed as the Megakaryocyte Glycogen Score (MGS).

3. The megakaryocyte glycogen scores on 25 aspirations from 14, healthy, young adult volunteers are presented and fall between 20 and 80, except in those subjects with recent acute blood loss or repeated phlebotomies over a period of years.

4. Subjects who have had repeated phlebotomies tend to have higher MGS than subjects without repeated phlebotomies. These higher values of MGS exist in the absence of abnormalities in the reticulocyte count, bone marrow differential count, platelet count, hemoglobin, hematocrit, wbc and differential, and rbc.

5. In one subject with a normal MGS, a 500 cc. phlebotomy was followed in one hour by a decrease in MGS. The MGS had increased above normal by four hours postphlebotomy and was still elevated 25 days after phlebotomy.

6. Implications of these observations are discussed.
SUMMARIO IN INTERLINGUA

1. Es describite le distribution de structuras glycogenic e non-glycogenic in megacaryocytes in tanto que demonstrabile per le technica de Hotchkiss.

2. Esseva disvelopate e es describite un methodo pro estimar le quantitates relative de glycogeno megacaryocytic in un aspiration de medulla ossee. Le resultato es exprimite como le Indice de Glycogeno Megacaryocytic (IGM; in le texto = MGS).

3. Le magnitudes de MGS in 25 aspirationes ab 14 normal juvene voluntarios adulte es presentate. Illos se trova inter 20 e 80, excepte in subjectos con recente acute perditas de sanguine o repetite phlebotomias effectuate in le curso de plure annos.

4. Subjectos qui ha experientiate repetite phlebotomias tende a monstrar un plus alte MGS que subjectos qui non ha experientiate repetite phlebotomias. Iste augmentate valores de MGS existe in le absentia de anormalitates in le numeration de reticulocytos, in le numeration differential del medulla ossee, in le numeration de plachettas, in le hemoglobina, le numeration leucocytic, le numeration differential, e in le numeration erythrocytic.

5. In un subjecto con un normal MGS, un phlebotomia de 500 cm³ esseva sequite in un hora per un reduction del MGS. Quatro horas post le phlebotomia, le MGS esseva supranormal. Illo esseva ancora supranormal 25 dies post le phlebotomia.


REFERENCES


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Studies of Megakaryocyte Glycogen. I. A Semiquantitative Method of Measurement: Effect of Phlebotomies in Young Adults

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