An Index for the Evaluation of Arteriosclerotic Lesions in the Abdominal Aorta

A Report by the Committee on Lesions of the American Society for the Study of Arteriosclerosis*

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The need for uniform and reproducible methods to grade the lesions of arteriosclerosis has long been recognized.

In this report are presented pro tempore the results and recommendations of the Committee on Lesions of the American Society for the Study of Arteriosclerosis based on studies of the abdominal aorta of man during the past 3 years. The methods may prove useful in other parts of the arterial system and thus facilitate basic studies on arteriosclerosis in man and in animals.

It should be emphasized that this approach to the quantitative evaluation of aortic lesions does not preclude combining it with other methods of measuring the degree of disease in a given vessel. Physical or chemical measurements of many types can be made on the same vessels.

Methods

(1) Anatomic material was preserved for repeated studies. Opened, flattened, formalin-fixed segments of the aorta preserved in plastic bags with coded labels proved convenient for this purpose. Repeated observations using a variety of criteria for assessment were made on the material by 7 pathologists and their associates. The observations reported here were all of a simple type that could be made by inspection alone or inspection aided by some simple measuring device such as a centimeter scale.

(2) A biostatistician served as referee and coordinator of the studies.

(3) The systems of grading that were studied took cognizance of the quantitative and qualitative aspects of the lesions.

(a) Quantitative estimates were expressed as the percentage of intimal surface area that showed arteriosclerosis.

(b) Qualitative features of the individual lesions usually allowed them to be classified on inspection as:

(1) Fatty lesions (fatty streaks or predominantly fatty plaques).

(2) Fibrous plaques or diffuse thickening of the intima.

(3) Complicated lesions (old or recent hemorrhage, ulceration, thrombosis, calcification).

These three qualitative estimates were then expressed quantitatively as a percentage of the abnormal surface area and, consequently, they always totaled 100 per cent.

When fatty deposits were difficult to visualize, it was found useful to stain the whole vessel with a fat-soluble dye such as Sudan IV.

Calcification, both intimal and medial, was assessed separately but it was found in practice that it could ordinarily be included in the percentage of qualitative change recorded as complicated lesion. In certain cases, calcification could be felt in the gross specimen lying beneath an intact intimal surface in which there were no obvious complications. Its presence was confirmed by histologic and radiologic studies. The appropriate assessment of these lesions remained unresolved, but they did not seriously interfere with the use of the simple methods outlined above. Table 1 shows the form used in recording the data.

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†For the purposes of this study arteriosclerosis has been used to indicate the involvement of the intima which can be seen and evaluated grossly. The components of the lesions which have been included are (1) fatty streaks and plaques; (2) fibrotic intimal thickening; and (3) complicated lesions which include hemorrhage, ulceration, thrombosis, and calcification.

††Deceased.
(4) **Assessment by ranking**: In addition, groups of abdominal aortas were arranged or ranked to form series in which each specimen was judged to be more severely affected with arteriosclerosis than the preceding one.

(5) **Topographical features** of the lesions were kept relatively constant by studying only the abdominal aorta from the inferior margin of the celiac axis to a line drawn across the top of the point of bifurcation into the iliac arteries. No attempt has been made to describe the topographical features of lesions in this report. They vary in different anatomical areas.

**Materials**

A. Twenty-six aortas were chosen from 120 aortas submitted (20 each) by the members of the Committee from 6 different cities of North America. These were selected by the biostatistician with assistance from a pathologist who had experience with arteriosclerosis but was not otherwise active in the present study. The specimens were chosen to provide a series that would encompass the gamut of quantitative and qualitative changes encountered in aortas in North America. After each member of the Committee had graded the quantitative and qualitative aspects of the lesions he was requested to arrange or rank on a subsequent day the 26 specimens in what he judged to be the order of severity of involvement by arteriosclerosis. The specimens were placed in random order by the biostatistician after each ranking. This group of specimens was again graded and ranked by the same observers in another city approximately 1 year later.

B. Twenty-five human abdominal aortas were collected consecutively on the Louisiana State University Service at Charity Hospital, New Orleans. This group was graded and ranked by each member of the Committee.

C. Thirty aortas from the University of Chicago Clinics were selected to span the range of intimal disease. This group was also graded and ranked by each member of the Committee.

The aortas in groups B and C were also ranked by a resident in pathology and a junior member of a department of pathology who had no previous contact with the work of the Committee.

**Results**

The data for each of the 3 groups of aortas were analyzed separately. The rankings given independently by the several judges who arranged the aortas in order of their severity of involvement by arteriosclerosis were examined to see if the agreement between the six judges
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was good enough to justify an index related to the severity of arteriosclerosis. The severity rank data are presented in figures 1, 2, and 3. The coefficients of concordance are high: 0.97, 0.93, and 0.96 for groups A, B, and C respectively.

The degree of subjectivity of the visual estimates of percentage of intimal surface involved by lesions was examined. Figures 4, 5, and 6 show the data for estimation of over-all area covered with arteriosclerotic lesions \( P_T \). For aortas approximately 50 per cent involved the judges agreed to within \( \pm 20 \) per cent. In an occasional aorta (2 of 26) the interpretation of large areas of diffuse fibrous intimal thickening caused important disagreement. In general, the agreement was better for the more diseased and for less diseased aortas. There was less agreement among the judges in estimating the percentages of the different types of lesions. For example, the visual estimates for fibrous plaques by the seven judges varied from 10 to 60 per cent on an occasional specimen; and this magnitude of variation could also be found in the visual estimates for complicated lesions. This degree of variation, however, was the exception rather than the rule; and no consistent variation—or "correction factor"—for any 1 of the 7 judges emerged from a careful study of all the recorded data.

The index constructed from the quantitative estimates of the percentage area involved by the several types of lesions is of the form

\[ \text{INDEX} = \sum \frac{P_T}{n} \]

where \( P_T \) is the percentage area covered with arteriosclerotic lesions and \( n \) is the number of lesions.

\[ \text{INDEX} = \frac{100}{n} \]

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VARIATION IN INDIVIDUAL ESTIMATES OF
PERCENT LESION AREA

GROUP A.

MINIMUM AND MAXIMUM INDIVIDUAL ESTIMATES OF PERCENT LESION AREA

AVERAGE PERCENT LESION AREA

Figure 4
Estimation of total diseased intimal surface of aortas of group A.

VARIATION IN INDIVIDUAL ESTIMATES OF
PERCENT LESION AREA

GROUP B.

MINIMUM AND MAXIMUM INDIVIDUAL ESTIMATES OF PERCENT LESION AREA

AVERAGE PERCENT LESION AREA

Figure 5
Estimation of total diseased intimal surface of aortas of group B.


d and complicated lesions (C), respectively. The constants, B, are weights determined so as to obtain maximum agreement between the index values and the severity rankings within a group of aortas.

The rankings were transformed to expected values of the order statistics for a normal distribution with mean 50 and standard deviation 20. The transformed values and the value of PT, PF, and PC were used to obtain least-squares estimates of BT, BF, and BC.

It should be noted that, since the sum of the percentages of intimal surface affected by the three types of lesions studied (fatty, fibrous, and complicated) must equal 100 per cent of the total area involved by lesions, only 2 of the 3 types of lesions are represented directly in the formula, the third type (fatty lesions) being represented indirectly.

The statistically determined weights, B, were calculated separately for each of the 3 groups. The results were:

Group A: $I = .51P_T + .15P_F + .57P_C$
Group B: $I = .45P_T + .27P_F + .64P_C$
Group C: $I = .54P_T + .26P_F + .47P_C$

On the basis of the results the index for the

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evaluation of arteriosclerotic lesions, \( I = 1/2P_T + 1/4P_F + 1/2P_C \), is proposed for the human abdominal aorta. While it may be more generally applicable, it should be noted that it has been devised by use of specimens from the general autopsy population in North America. The weighting coefficients are compromise values based on the least-squares solutions; they are easy to remember and use; and they make the maximum value of the index exactly 100.

**Comment**

The index does not have etiologic or pathogenetic implications. It is based on the simple, visual inspection of arteriosclerotic lesions carefully observed and recorded by pathologists. The study has elicited a high degree of concordance among the several observers. Nevertheless, the method is subjective and, consequently, it can be distorted by inexperience, unusual criteria, or carelessness. On the other hand, preliminary study indicates that very little experience with the pleomorphism of arteriosclerotic lesions is required before adequate and reproducible assessment is possible. The method is rapid and requires no special equipment, although it may be useful to stain specimens from young individuals and from animals with a fat-soluble dye. It is capable of providing a relatively uniform evaluation of arteriosclerotic lesions within the same laboratory or between different laboratories. Since the index is related to the severity of arteriosclerosis as ascertained by ranking procedures, it will predict the place of a specimen in a series ranked in severity.

**Summary**

An index for the evaluation of arteriosclerotic lesions based on visual observation of selected and unselected specimens of the abdominal aorta was derived from a statistical analysis of simple grading and ranking studies.

This index, \( I = 1/2P_T + 1/4P_F + 1/2P_C \), takes cognizance of most of the grossly visible quantitative and qualitative features of human arteriosclerotic lesions. In it \( P_T \), \( P_F \), and \( P_C \) are the quantitative estimates of the percent of total area diseased (T) and the percent lesion area with fibrous plaques (F) and complicated lesions (C), respectively. The index is subjective but relatively reproducible by the same or different observers. It does not carry any implications of etiology or pathogenesis. The work of the Committee is continuing, and it is hoped that indices based on such methods may prove useful when applied to other parts of the arterial system or in studying several parts simultaneously, thus facilitating basic studies on arteriosclerosis both in man and in animals.

**Acknowledgment**

Assistance from many consultants is gratefully acknowledged.

**Summario in Interlingua**

Un indice pro le evalutation de lesiones arteriosclerotic, basate super le observation visual de seligitite e non-seligitite specimen de aorta abdominal eseva derivate ab le analyse statistic de simple studios de marcation e seriation relative.

Iste indice, \( I = \frac{1}{2}P_T + \frac{1}{4}P_F + \frac{1}{2}P_C \), prende in consideration le majoritate del grossiermente visible caracteristicas quantitative e qualitative de lesiones arteriosclerotic human. In illo, \( P_T \), \( P_F \), \( P_C \) es estimations quantitative del procentatge de terreno morbide total (T) e del procentatges del terreno morbide que exhibi placas fibrose (F) e lesions complicate (C), respectivamente. Le indice es subjective, sed illo es relativamente reproducible per le mesme o per un altere observator. Le indice ha nihil a signalar ab le puncto de vista del etiologia o del pathogene.

Le labores del committee va continuar, e le spero es exprimite que indices de iste genere va esser utile quando illos es applicate a altere partes del sistema arterial o quando pure partes es studiate simultaneemente. Isto renderes plus facile le studio fundamental de arteriosclerosis in humanos e animales.

**References**


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To such it might, perhaps, be a sufficiently philosophical answer to reply, that an improved knowledge of the nature and causes of a disease, must alone necessarily lead to an improvement in the treatment; and that therapeutic weapons are dangerous when wielded in the dark.—J. Hope, M.D. Diseases of the Heart and Great Vessels. London, William Kidd, 1832, p. 19.
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