Grading Human Atherosclerotic Lesions
Using a Panel of Photographs

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SUMMARY
The American Heart Association’s Committee on Grading Lesions of the Council on Arteriosclerosis has devised a method of grading the severity of atherosclerosis in human coronary arteries and aortas. The method uses two series of color photographs of arteries arranged in increasing severity of atherosclerosis. The Committee tested the method for inter-observer reproducibility by exhibiting the panel at two national scientific conventions and inviting visitors to grade a set of arteries with the panel. The test demonstrated a reasonable degree of inter-observer reproducibility despite a wide range of experience and disciplinary background. Inter-observer variability decreases with increasing experience in working with atherosclerotic lesions. Training graders who participate in a study may reduce inter-observer bias. For populations with predominantly less or predominantly more atherosclerosis, the investigator should construct special panels with different ranges of severity. The Committee revised the panel in the light of the results of the two exhibits and the comments of users in a field trial. The revised panel provides seven possible scores for each coronary artery and for each aorta. This panel provides a relatively simple and speedy quantitative method of comparing autopsy data on atherosclerosis among many kinds of studies and has the added advantages of facilitating comparisons between different geographic locations and different times.

Additional Indexing Words:
Observer bias  Coronary sclerosis  Aortic atherosclerosis

THE COMMITTEE on Grading Lesions of the Council on Arteriosclerosis has devised and tested a method of grading coronary and aortic atherosclerosis using a panel of photographs. The method yields reproducible values even when observers represent
different disciplines and degrees of experience. Such a panel may be useful in estimating and reporting the severity of atherosclerosis in autopsied persons and may facilitate surveys of atherosclerosis that involve geographically separated pathology laboratories.

The Committee that carried out this study was appointed by the Council on Arteriosclerosis of the American Heart Association (then, the American Society for the Study of Arteriosclerosis) in 1956. The late Dr. Russell L. Holman was the first chairman. The Association instructed the Committee to investigate the grading of human atherosclerotic lesions and to make known its findings. Initial efforts were focused on lesions of the abdominal aorta.

The Committee compared several different grading schemes. It found that ranking groups of 15 to 30 aortas by disease "severity" was highly reproducible among pathologists, even among individuals with little training in pathology and without research experience in atherosclerosis. Estimating the percent of intimal surface covered by lesions was less reproducible than ranking, but was sufficiently reproducible to be useful. From data accumulated by the Committee, the biostatistician devised a formula that related severity ranking to percent of intimal surface covered by lesions.1

The Committee turned its attention to the coronary arteries and found that, as the arteries became smaller, the problem became larger. Differences among observers were greater in estimating the extent of coronary artery lesions. Severity ranking remained highly reproducible, but this method could serve only for small groups of specimens. The Committee therefore sought other methods.

The method of grading specimens by using a graded series of models or photographs is well known. Wilens and Plair2 used this method to grade aortic atherosclerosis. The Committee investigated various methods of preparing models and photographs of arteries and conducted preliminary studies of the feasibility of such a technique. As another test, the Committee prepared panels of color photographs of selected coronary arteries and aortas and incorporated the panels into a convention exhibit. The data gathered from the responses of visitors to the exhibit form the basis of this report.

Methods

Aortas and right coronary arteries were removed from autopsied persons, opened longitudinally, washed with saline, and flattened. The arteries were photographed immediately and were photographed again after 24 hours of fixation in 10% neutralized Formalin. The Committee accumulated photographs of approximately 250 aortas and 150 coronary arteries from which to make the final selection.

The Committee selected nine photographs of aortas and nine of the coronary arteries that represented a stepwise increasing severity of atherosclerosis in a world-wide population of adults. The photographer made final prints on Ektacolor* paper with aortas at life size and coronary arteries at a 120% magnification.

The artist mounted the trimmed prints vertically on a blue background, inserted vertical strips to the left of the first photograph, to the right of the last photograph, and in each interval. He numbered the strips 1 through 10. Thus, the nine photographs provided 10 intervals of graded severity.

Technicians prepared the arteries to be evaluated in a manner similar to the arteries that were photographed, and preserved them in clear plastic bags.3 The Committee selected 20 coronary arteries and 20 aortas for each of the two duplicate panels in the exhibit and asked each visitor to grade all 40 specimens. The Committee showed the exhibit at the meeting of the American Heart Association in Cleveland, Ohio, in October 1962, and at the meeting of the American Association of Pathologists and Bacteriologists and the International Academy of Pathology in Cincinnati, Ohio, in April 1963.

The grading forms gave brief instructions and requested comments of the observer.

Results

Inter-Observer Reproducibility

For the first exhibit, aorta scores were usually within three grades at each end of the scale, but were spread over up to five grades in the middle. The coronary artery

*Registered trade mark, Eastman Kodak Co., Rochester, N. Y.
grades showed the same pattern, but the spread was greater at all levels than for aortas. This increased spread confirmed the experience of the Committee that coronary arteries were more difficult to grade reproducibly than were aortas. Pathologists showed as high variability in scoring in the middle range as the more heterogeneous AHA graders.

Effect of Experience on Grading

Each grader classified himself regarding experience. There was little tendency for the median to vary with experience level of the grader, but graders with greater experience tended to have less variability.

Bias in Graders

We examined the gradings for frequency and extent of consistent bias in graders—that is, a tendency for a person to grade consistently higher or lower than the median. Examples of such bias in each direction were numerous and in some cases bias was severe. Bias was less for aortas than for coronary arteries.

Discussion

General Conclusions

The results of this trial indicate that a high degree of reproducibility can be achieved in grading coronary and aortic atherosclerosis using a standard series of color photographs. This conclusion appears to be true whether the graders are experienced or inexperienced. Another substantial advantage of this method of quantitating the severity of atherosclerosis is that valid comparisons can be made in widely separated parts of the world or in widely separated points of time. With an improved panel of photographs of a graduated series of coronary arteries and aortas, one should be able to compare atherosclerosis in autopsied persons in England with atherosclerosis in autopsied persons in the United States. One might also be able to compare the severity of the disease in persons autopsied in 1967 with that in persons autopsied in 1977. Furthermore, large scale studies designed to determine the effects of diet, drugs, or intercurrent disease on the severity of atherosclerosis should be facilitated by the widespread use of this grading method.

Controlling Bias and Variability

The principles of standardization and quality control that apply to any laboratory determination apply to grading atherosclerosis. Measures to detect and eliminate bias in grading are relatively simple even though two or more graders in different locations are involved. More than one person in each institution may grade the specimens; graders may exchange sets of specimens to determine bias; or all specimens may be submitted to one grader or to all graders. The data from this trial suggest that training reduces bias, or variability, or both, and that training graders also reduces grading error.

Suggested Revisions in the Panel

The higher variability and greater difficulty in scoring specimens in the middle range led many graders to suggest a smaller number of gradations in the panel—for example, four instead of nine. Although a smaller panel may be easier to use, grades subdivided into only four grades would detect only the coarsest differences. If the investigator is looking only for great differences, such a panel might serve his purpose. The Committee reached a compromise in a revised panel.

Grading Stenosis

The Committee and the graders at the exhibits agreed that a panel of photographs of opened arteries is a relatively poor method of measuring the severity of coronary stenosis. Other methods, such as postmortem angiography or casts may be required to assess accurately coronary stenosis. The Committee has investigated this problem intensively and its conclusions are contained in another report.

Grading Other Coronary Arteries

The panel described here used only the first 6 cm of each right coronary artery because this branch was simpler to dissect and subject to less anatomic variability than either
Figure 1

Revised grading panel.

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the circumflex or the left anterior descending branch. Undoubtedly, the panel can be applied with similar results in grading the left coronary branches.

**Designing Panels for Special Studies**

The purpose of any grading instrument determines its design. If this panel of arteries is used for persons with severe atherosclerosis who die at age 60 to 70 years, most of the arteries will fall at the higher end of the scale. The discriminatory value of the panel will be greatly reduced. For a population of younger individuals with mild atherosclerosis, most arteries will fall at the lower end of the scale and the usefulness of the method will be similarly decreased. For studies within such groups, special panels can be devised to give maximum sensitivity in the desired range. A special panel can be related to this panel by including in it two or more of the panel photographs.

**Development of a Working Model**

Encouraged by the results of this exhibit, color prints of the unfixed arteries were incorporated into a new master panel. The photographs were of unfixed arteries, but otherwise the panel was identical to that used in the exhibit. A photographic laboratory prepared 100 dye-transfer color prints and mounted them on composition board. The Committee distributed these to persons performing research in atherosclerosis and to pathologists who wished to use them for autopsy reports. Later, the Committee solicited comments on the usefulness of the panels.

The most frequent objection was that the coronary artery photographs were of poor quality, and the next most frequent objection was that matching specimens in the midportion of the panel was difficult. We photographed a new series of coronary arteries and printed them about 2.5 times their natural size, and reduced the number of standards in the panel to six coronary arteries and six aortas. Matching to the nearest interval therefore provided seven possible scores (fig. 1).

This master panel was reproduced photographically in 100 copies and the prints were mounted between sheets of a polyester resin. The finished panel is 36 inches wide and 25 inches tall. The Committee will distribute the first 100 copies of the panel without charge to qualified investigators. When the supply is exhausted, if demand is sufficient, the American Heart Association will prepare additional copies and distribute them at cost.

**Acknowledgment**

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Mr. Harold Coletta, Montreal, Canada, made the photographs of aortas, and Mr. Gene Wolfe, New Orleans, made the photographs of coronary arteries.

**References**


REPORT OF COMMITTEE ON GRADING LESIONS, COUNCIL ON ARTERIOSCLEROSIS, AMERICAN HEART ASSOCIATION: Grading Human Atherosclerotic Lesions Using a Panel of Photographs

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