



Original Article

Assessment of atherosclerotic luminal narrowing of coronary arteries based on morphometrically generated visual guides



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ABSTRACT

Background and aims: Determination of the degree of stenosis of atherosclerotic coronary arteries is an important part of postmortem examination of the heart, but, unfortunately, estimation of the degree of luminal narrowing can be imprecise and tends to be approximations. Visual guides can be useful to assess this, but earlier attempts to develop such guides did not employ digital technology. Using this approach, we have developed two computer-generated morphometric guides to estimate the degree of luminal narrowing of atherosclerotic coronary arteries. The first is based on symmetric or eccentric circular or crescentic narrowing of the vessel lumen and the second on either slit-like or irregularly shaped narrowing of the vessel lumens.

Methods: Using the Aperio ScanScope XT at a magnification of 20× we created digital whole-slide images of 20 representative microscopic cross sections of the left anterior descending (LAD) coronary artery, stained with either hematoxylin and eosin (H&E) or Movat's pentachrome stain. These cross sections illustrated a variety of luminal profiles and degrees of stenosis. Three representative types of images were selected and a visual guide was constructed with Adobe Photoshop CS5. Using the "Scale" and "Measurement" tools, we created a series of representations of stenosis with luminal cross sections depicting 20%, 40%, 60%, 70%, 80%, and 90% occlusion of the LAD branch. Four pathologists independently reviewed and scored the degree of atherosclerotic luminal narrowing based on our visual guides. In addition, digital technology was employed to determine the degree of narrowing by measuring the cross-sectional area of the 20 microscopic sections of the vessels, first assuming no narrowing and then comparing this to the percent of narrowing determined by precise measurement.

Results: Two of the observers were very experienced general autopsy pathologists, one was a first-year pathology resident on his first rotation on the autopsy service, and the fourth observer was a highly experienced cardiovascular pathologist. Interobserver reliability was assessed by determination of the intraclass correlation coefficient. The degrees of agreement for two H&E- and Movat-stained sections of the LADs from each of 10 decedents were 0.874 and 0.899, respectively, indicating strong interobserver agreement. On the average, the mean visual scores were ~8% less than the morphometric assessment (52.7 vs. 60.2), respectively.

Conclusions: The visual guides that we have generated for scoring atherosclerotic luminal narrowing of coronary arteries should be helpful for a broad group of pathologists, from beginning pathology residents to experienced cardiovascular pathologists.

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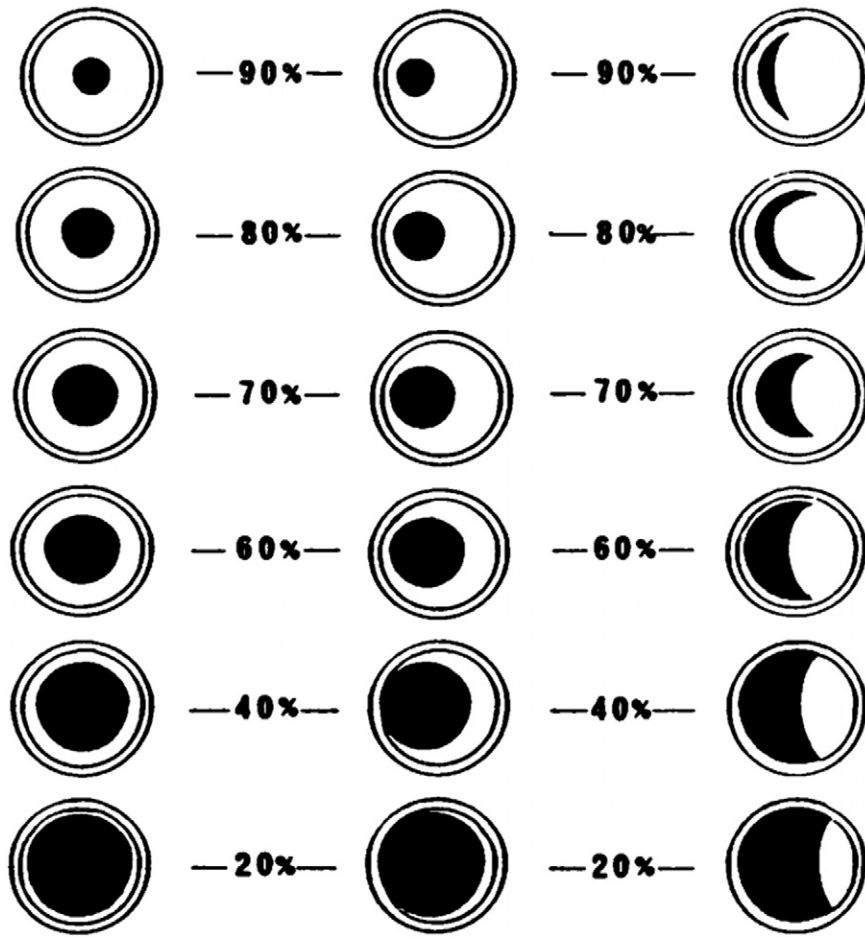


Fig. 1. Schematic diagram, originally published by Champ and Coghil [6], illustrating the percentage reduction in cross-sectional areas of atherosclerotic coronary arteries. The outer circle represents the exterior wall of the vessel, the inner circle represents the internal elastic lamina, the white represents the atheroma, and the black area represents the lumen.

1. Introduction

Examination of the heart is a major component of any complete autopsy. An important part of this is gross examination of the coronary arteries and determination of their involvement, if any, by atherosclerotic coronary artery disease. Determination of the degree and extent of atherosclerosis of the coronary arteries can be difficult, especially in nonperfusion fixed vessels of autopsy hearts [1]. Although there is an extensive literature describing quantitation of coronary arterial luminal narrowing by means of angiography, there is a lack of practical visual guides to assist pathologists in estimating the degree of luminal narrowing of the coronary arteries. Roberts, Jones, and Virmani [2–5] have published extensively on quantitation of coronary arterial narrowing at the time of necropsy but have not provided any visual guides to assess this. To the best of our knowledge, the schematic diagram developed by Champ and Coghil [6] illustrating the percentage reduction in cross-sectional areas of coronary vessels is one of the few such examples of a practical visual guide (Fig. 1), and the other is that of Ford et al. [7,8].

Based on the experience of several of us in the Department of Pathology at The Ohio State University, Champ and Coghil's visual guide has proven to be very useful for estimating the degree of luminal narrowing of histologic sections of coronary arteries. As stated by them, their schematic diagram "was designed to give a quick visual assessment of the degree of coronary artery stenosis at necropsy." [6] The method that was employed to develop this visual guide was not described, but it most certainly was not based on computer-based digital morphometry. This technique, described in detail in the present report, has allowed us to generate two visual guides that illustrate various types of

atherosclerotic luminal narrowing of the coronary arteries. To evaluate the usefulness of these guides, we have used them to visually estimate the degrees of luminal narrowing in 20 histologic sections of the left anterior descending (LAD) branch of the left main coronary artery of 10 decedents. These visual estimates then were compared to the degree of luminal narrowing determined from digitally generated images of the vessels that have been subjected to morphometric analysis. Based on this study, we have concluded that our visual guides should be of great practical use to pathologists for more accurately quantifying the degree of luminal narrowing of microscopic sections of atherosclerotic coronary arteries.

2. Materials and methods

2.1. Sample acquisition and processing

Hearts from a series of 10 autopsy cases from the time period extending from September to November 2016 were selected for the present study. The hearts were examined grossly intact before opening them by following the direction of blood flow, and the main coronary arteries, consisting of the right, left main, circumflex, and anterior descending branches, were identified. Serial cross sections were made in situ at 5-mm intervals for each of the vessels and two sections of the LAD branch, which showed the maximal amount of luminal narrowing, were taken for the present study. Those samples of formalin-fixed LAD coronary arteries that appeared to be calcified first were placed in a solution of 90% formalin and 10% Decal B solution (Fischer Scientific Co., Pittsburgh, PA, USA) for 1 to 2 days and then were surface decalcified at the time of sectioning. Vessel histology was evaluated on formalin-

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