Structure and Ultrastructure of the Coronary Artery Intima in Children and Young Adults Up to Age 29

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Introduction

This paper describes the intima of the coronary arteries of young human subjects as it develops and changes during maturation. The work represents a preliminary report of one part of a continuing study of the coronary arteries and aortas of the population of New Orleans in the first 29 years of life. Investigators who studied human coronary intima in the past found that it was thickened and that there was regional variation in thickness and structure. A thick intima was also reported for other arteries. Thoma (1) who studied human aortic intima with the light microscope, a century ago described and illustrated areas in which the intima was consistently thicker. He stated that the thick segments were a universal feature in human aortic development. Awareness of the fact that human arterial intima is far more than a thin and nondescript space between the basement membrane of the endothelial cells and the internal elastic lamina has, however, not been general.

The present study of coronary artery intima differs from the ones that preceded it in that the coronary arteries we studied and measured were fixed under pressures similar to those existing during life, that light microscopy was on 1-μm plastic-embedded sections which allow a resolution far superior to that of traditional 5-μm sections, that the 1-μm sections were complete cross-sections, and that we used semiserial sectioning and electron microscopy. The reason for this study was not only the wish to add to the basic knowledge about human coronary intima by using improved methods but the hope that we could answer some questions about the development of atherosclerotic lesions in some preferred coronary segments. The incidence of coronary atherosclerotic lesions in the young population and the mechanism of their development and progression will be the subject of subsequent reports.

Methods

The data in this report are on the coronary arteries of 276 black and white, male and female subjects aged up to 29 years. These were selected from more than 400 autopsy cases obtained so far for this project and from 50 autopsy cases used in a feasibility study preceding the project. The 276 cases were chosen for pressure-perfusion and morphological studies because of a shorter interval between death and autopsy. Most of the subjects died in accidents or homicides. As

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soon after death as possible, we perfusion-fixed the coronary arteries under a pressure of 100 mm Hg by connecting the ascending aorta by plastic tube to a container with 3% glutaraldehyde, elevated 135 cm above the level of the heart. The fixative drained through the coronary sinus and through a small peripheral artery incised at the apex of the heart. The pressure within the coronary arteries was not monitored during perfusion and some variation in the contour of the internal elastic lamina from case to case suggests that variation in the actual intracoronary pressure occurred. Variation was within limits and we are confident that the comparisons which we base on our measurements are nevertheless valid.

Although a thick intima occurs in all coronary artery branches, we confined our coronary studies to a detailed investigation of a precisely defined segment of the left coronary artery, consisting of the main stem, the main bifurcation, and the proximal left anterior descending (LAD) branch. We already knew that intimal thickening is prominent in these segments, and that coronary artery disease, if it will occur at all, will develop preferentially in this location. Limiting the study to a precisely defined segment made study in depth feasible. We studied the same coronary segment in several nonhuman primate species also. We cut the segment into five consecutive tube-like blocks (main, bifurcation, LAD 1, 2, and 3), each measuring 2 to 3 mm in length, and embedded these in the epoxy resin Maraglas or, in some instances, in water-soluble methacrylate. Measurements were made on the 1-μm thick cross-sections of the plastic-embedded coronary segments. For comparative measurements of intimal and medial thickness we used only the three blocks of the proximal LAD branch, because media and intima are well defined in the LAD. While we did also measure the intima and its points of emphasis in the main stem and in the bifurcation, we used the results of these measurements with reservation since the intimal-medial boundary is often ill defined in the left main segment and at the bifurcation. We also did not use for comparisons of intimal thickness coronary arteries that had developed atherosclerosis. The three LAD blocks of twenty five cases were sectioned and measured semiserially. Thus in each one of 25 cases, measurements were made in about 30 complete cross-sections of the proximal LAD. Four separate measurements were made of each coronary cross-section, the thickest part of the wall constituting the first measurement, the other three measurements being at right angles to the first one. For measurement we used the light microscope containing an eyepiece disk with a scale subdivided into 100 segments. The eyepiece segments were converted into μm with a stage micrometer.

**Definition of Coronary Artery Intima**

The term coronary artery intima as we use it in this report refers to an intima in which one or more layers of intimal smooth muscle cells and a variable amount of glycosaminoglycan (GAG)-rich extracellular matrix separate the endothelial basement membrane from the internal elastic lamina or, in the absence of an internal elastic, from the first lamina of the media. Terms that are being frequently used for the thick intima of human coronary (and other) arteries and for the less severely and less extensively thick coronary artery intima of other species are diffuse intimal thickening (DIT) and nonatherosclerotic intimal thickening. Since it is established that the