A MICROSPECTROSCOPIC STUDY OF ARTERIOLES IN BENIGN AND MALIGNANT HYPERTENSION *

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Various histochemical procedures applied to normal human and canine arterioles, acutely necrotic arterioles of the dog following bilateral nephrectomy, acutely necrotic arterioles of man in malignant hypertension, and hyalinized arterioles of man associated with benign hypertension have yielded similar results for the area of the media.[1,2] These observations were considered to support the previous stand, based on transitions detected by less precise methods of staining,[3-7] that the change within the arterioles in these various conditions is the result of injury and subsequent alterations of the smooth muscle of the media. In these discussions[3-6] it was appreciated that other changes contributed to the ultimate lesion of arteriolar sclerosis, as for example the deposition of connective tissue elements within the various layers of the vessel wall, but the fundamental element in pathogenesis was considered to be injury and alteration of smooth muscle. The purpose of the present paper is to present data obtained by microspectroscopic analyses of the same lesions studied histochemically in two previous reports,[1,2] which can be considered to give further support to the thesis that the hyalin of hyaline arteriolar sclerosis is derived mainly from the fusion of degraded products of smooth muscle of the media.

METHODS

The material from man and the dog considered herein was that previously studied histochemically.[1,2] The human material consisted of the lesion of acute arteriolar necrosis in the kidney of a patient dying with classical malignant hypertension and of those of hyaline arteriolar sclerosis in the kidneys of 4 necropsied patients with classical benign hypertension. One of these had severe diabetes with nodular glomerular sclerosis. The normal or control human arteriole was obtained from the periadrenal fat of a young adult who died from trauma. The example of acute arteriolar necrosis of the dog was obtained from a hypertensive bilaterally nephrectomized dog maintained as previously

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described.[7] The normal canine arteriole was obtained by the sacrifice of a healthy adult mongrel dog.

In each instance, one arteriole was studied in one frozen section of formalin-fixed tissue. The frozen sections were cut at approximately 6 μ and mounted unstained in glycerin on Vycor* slides with Vycor* coverslips. The arteriole to be studied was selected and brought into focus with visible light. By means of a grating monochromator† with a hydrogen arc source and reflecting quartz optics,† monochromatic light at intervals of 5 mμ from 250 to 360 mμ was passed through the tissue section and the image recorded on S. A. No. 1 film‡ held in a 35 mm. gamma camera back. The exposure time for each wave length differed and was predetermined with a blank slide so that a constant background density of the film was obtained at all wave lengths. The photographs thus obtained represent comparative absorptions at various intervals and may be compared quantitatively for any one lesion. Since no effort was made to control accurately the thickness of the preparation or the distribution of the material within the lesion, one lesion could not be compared quantitatively with another. However, the lesions could be compared qualitatively from the curves obtained by plotting the direct densitometric readings of the image as recorded by the film against the wave lengths of light. To obtain these readings the image of the lesion on the film at each wave length was masked and placed in front of a densitometer§ head while a constant source of visible light was passed through the film to the densitometer. Variations in the densitometer readings at various wave lengths thus represented variations in the absorption characteristics of the material photographed. By comparing the shapes of all the curves so obtained one could appraise the nature of the absorbing substances in each case.

Results

Text-figure 1 is a composite graph of the curves of the normal and abnormal human and canine arterioles. The curves represent the film densities plotted against wave length in millimicrons. These curves show similar absorption patterns, which indicate a very high absorption from 250 to 290 mμ. At the latter wave length all of the curves rise, indicating less absorption of the light at subsequently higher wave lengths. The height of the rise is not the same in all cases, although the

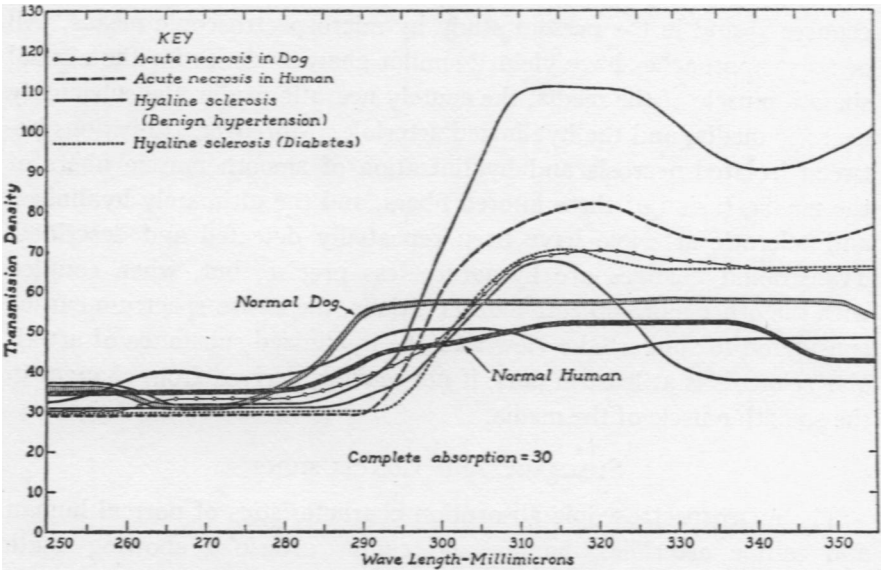
* Vycor slides and coverslips from A. D. Jones Optical Company.

† Bausch & Lomb reflecting optics, grating monochromator with hydrogen arc light source.

‡ S. A. No. 1 film from Eastman Kodak Company.

§ Photovolt densitometer, Model 520M.

curves show a similar distribution from 290 to 350 mμ. These data indicate that the absorption characteristics of normal human and canine arterioles, acutely necrotic human and canine arterioles, and hyaline human arterioles are similar from 250 to 350 mμ.



Text-fig. 1. Microspectroscopic absorption curves for wave lengths from 250 to 350 mμ for normal human and dog arterioles, acutely necrotic human and dog arterioles, and hyaline human arterioles.

In the normal and the necrotic arteriole the main tissue concerned in the absorption pattern is the smooth muscle of the media. The finding that the hyalinized arteriole of arteriolar sclerosis has the same absorption characteristics as its necrotic counterpart is considered an additional indication of origin of the hyaline material from smooth muscle. This is demonstrated by Figures 1 to 6, which represent the absorption photographs of a hyalinized arteriole from case 4 of Montgomery and Muirhead[2] at 255, 285, 290, 295, and 345 mμ and visible light, respectively. Normal vessels, vessels with acute necrosis, and hyalinized vessels show essentially the same photographic pattern as indicated by the absorption curves reproduced in Text-figure 1.

The precise chemical nature of the absorbing substances in each of the cases cannot be determined by an analysis of these absorption curves. Normal and abnormal arterioles are known to contain a wide variety of substances, demonstrable by histochemical means, including lipids, carbohydrates, free carbonyl groups, protein-bound sulfhydryl groups, and free potassium; the normal vessels and the acute necrotic

arterioles contain acid phosphatase in addition, while the hyaline arterioles have not given this enzymatic reaction.[1,2]

In this institution, normal arterioles, necrotic arterioles, and hyalinized and sclerotic arterioles have been studied by a battery of conventional staining procedures,[3-7] a battery of histochemical procedures,[1,2] and in the present study by microspectroscopic means. All of these approaches have yielded similar characteristics for the normal smooth muscle of the media, the acutely necrotic media, the subacutely necrotic media, and the hyalinized arteriole. Moreover, transitions between isolated necrosis and hyalinization of smooth muscle fibers of the media, fusion of these altered fibers, and the ultimately hyalinized and sclerotic arteriole have been repeatedly detected and described. Transitional changes are by nature less precise, but, when coupled with the other more objective observations, the entire spectrum can be considered to support the view that the hyalinized substance of arteriolar sclerosis is at least in part, if not mainly, derived from changes in the smooth muscle of the media.

Summary and Conclusions

The microspectroscopic absorption characteristics of normal human and canine arterioles, human and canine arterioles showing acute arteriolar necrosis, and human arterioles showing hyaline sclerosis were determined and compared by direct film densitometry.

The absorption curves of these normal and abnormal arterioles show complete absorption from 250 to 290 μ. From 290 to 350 μ the curves show incomplete absorption and are qualitatively similar.

These data support the view that the acute arteriolar necrosis of the bilaterally nephrectomized dog, the acute arteriolar necrosis of human malignant hypertension, and the hyaline sclerosis of human benign hypertension have a common pathogenesis related to alterations of the smooth muscle of the arteriolar media.

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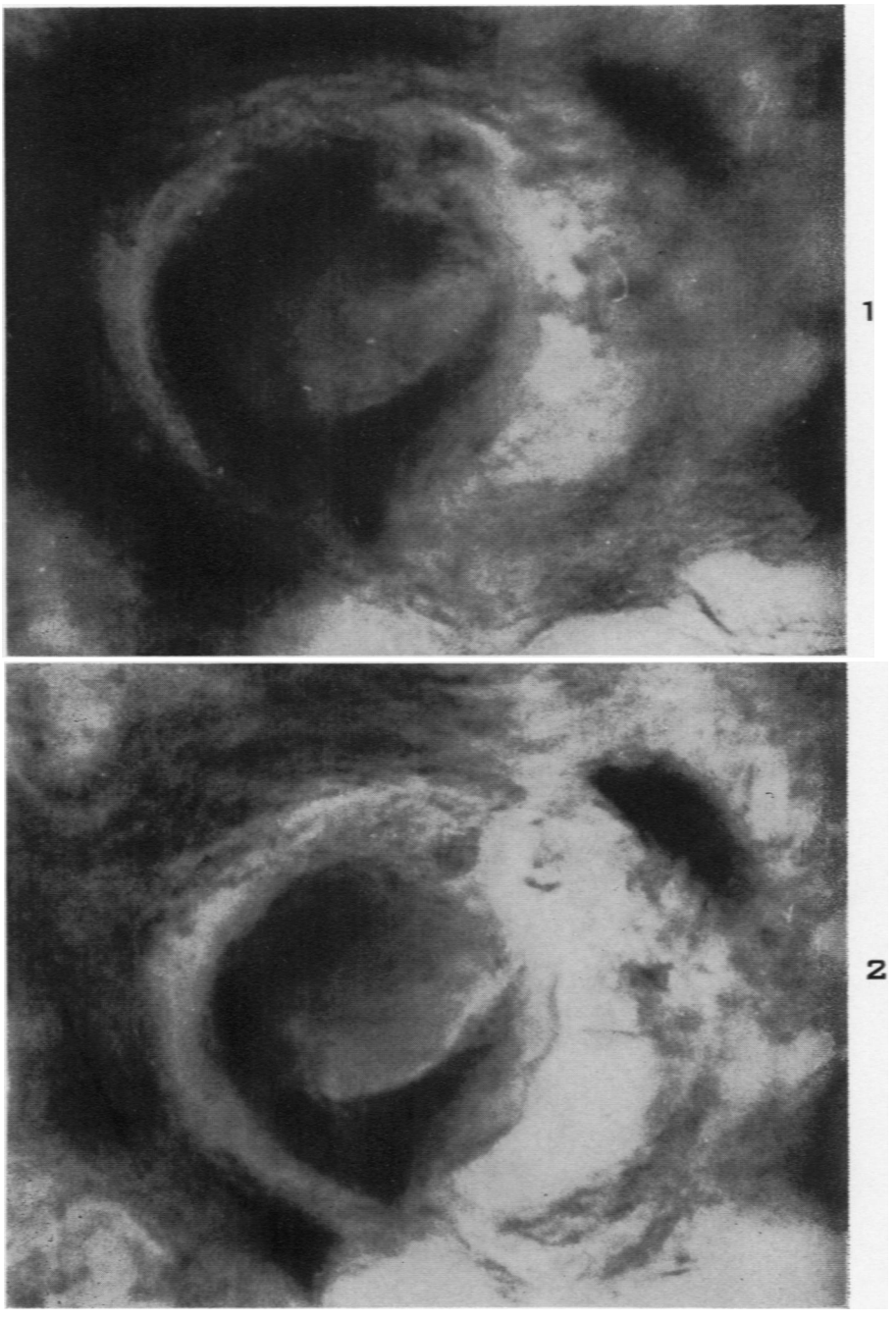
[*Illustrations follow*]

LEGENDS FOR FIGURES

All illustrations show the same hyaline arteriole from case 4 of Montgomery and Muirhead,[2] in unstained formalin-fixed frozen sections. Magnification, 53 ×. Enlargement, 150 ×. Wave length used as indicated in the individual legends.

FIG. 1. 255 millimicrons.

FIG. 2. 285 millimicrons.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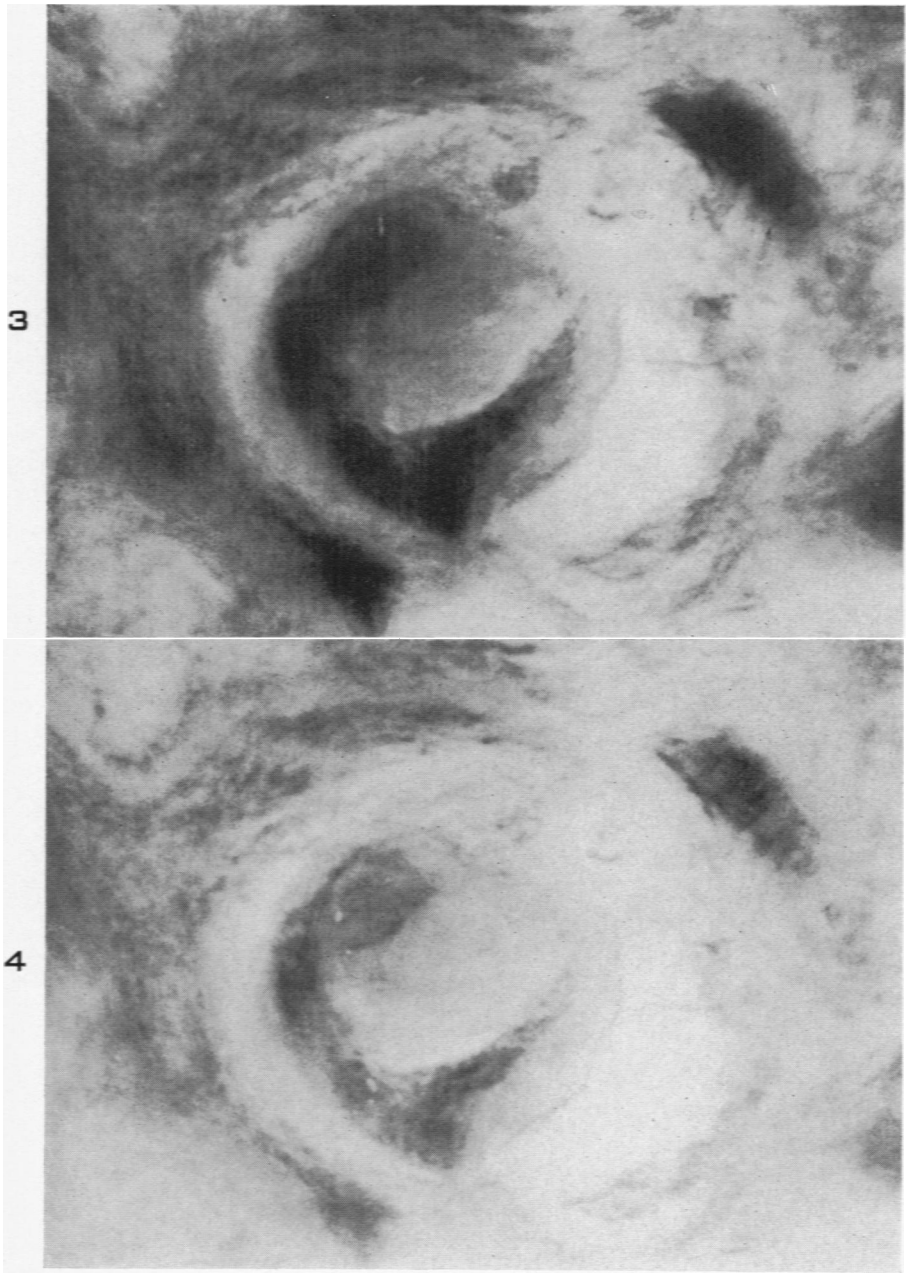
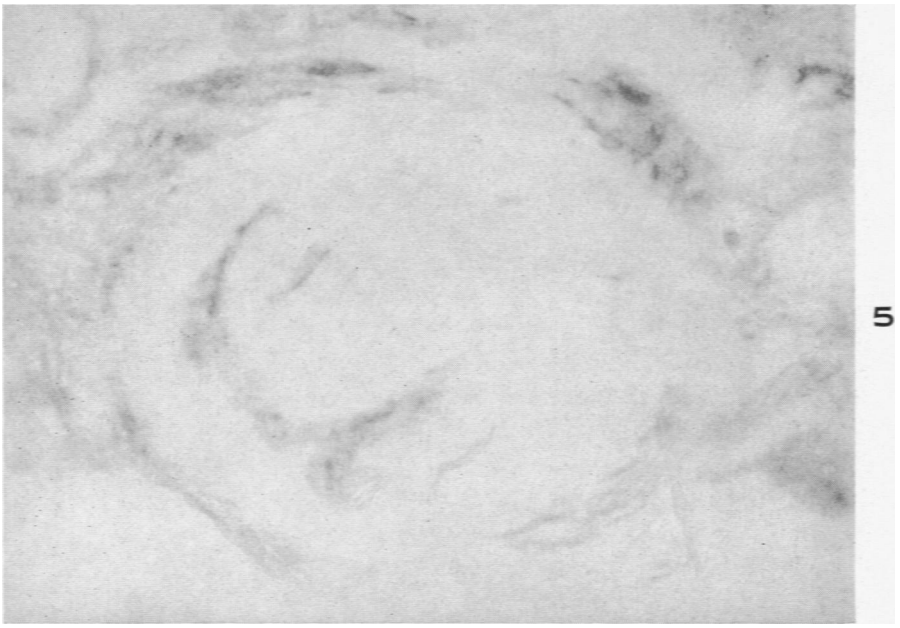


FIG. 3. 290 millimicrons.

FIG. 4. 295 millimicrons.

FIG. 5. 345 millimicrons.

FIG. 6. Visible light.



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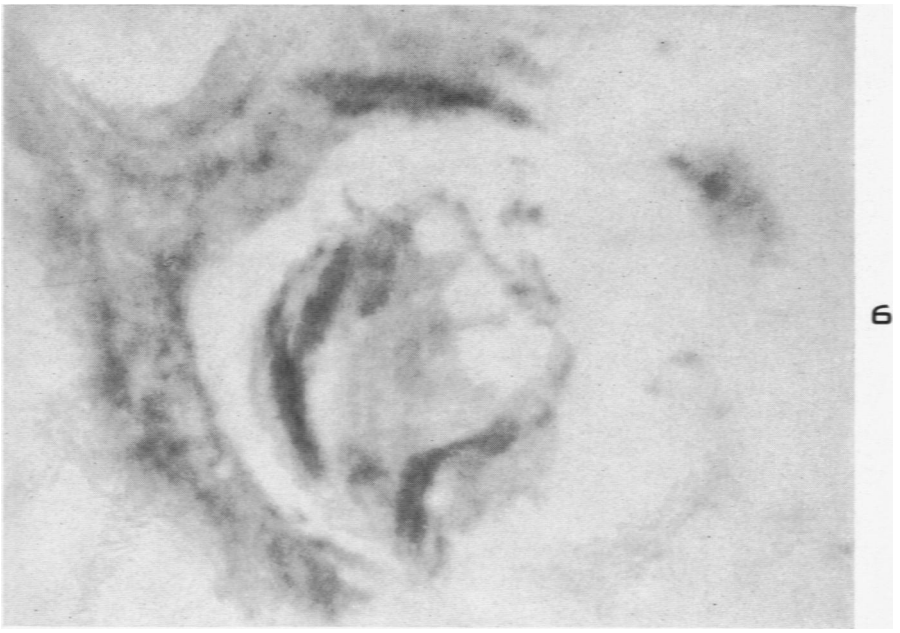

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