Studies on the Nervous Control of the Renal Circulation

—Based on the Morphologic Observations—

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In order to clarify the mechanism of the nervous control of the renal circulation, the neurility of the kidney was investigated morphologically with special reference to the relation of the nerves to the blood vessels.

The development of the vessels and nerve fibers in the fetal kidney—

The nerve fibers enter the kidney between the 2.8 and 5.0 cm stage in the human embryo, and before the 3.2 cm stage in the dog embryo. Thereafter, the innervation of the fetal kidney develops progressively. And many delicate nerve fibers are observed along the vessels in the juxtamedulla and the cortico-medullary junction. But, in the outerpart of the cortex, the vessels and glomeruli are very immature, and any nerve fibers cannot be observed. Therefore, the development of the innervation of the fetal kidney seems to be parallel to that of the glomeruli and vessels.
The innervation of the adult dog kidney—

The innervation of the blood vessels in the renal parenchyma: The nerve fibers follow the branches of the renal artery (interlobar, arcuate and interlobular arteries, and afferent arterioles) and approach the glomeruli. The bulk of them are found in the adventitia where they form the well-developed plexus. Many delicate fibers come out from the plexus and flow into the terminal net system built up of the anastomosing network of the Cajal's interstitial cells. The veins are supplied with a few nerve fibers which come from the plexus around the arteries.

The innervation of the glomeruli: The nerve fibers run along the afferent arterioles and approach the glomeruli. Most of the fibers pass from the afferent to the efferent arterioles without entering the glomeruli. It is supposed that these nerve fibers may play an important role on the nervous control of the glomerular blood flow.

The innervation of the juxtaglomerular cells: An abundance of the nerve networks are observed to surround the juxtaglomerular cells and some fibers of the networks are found to attach to the macula densa closely. It is apparent that the juxtaglomerular cells and the macula densa have a close relation to the nerves.

The innervation of the juxtamedulla and the medulla: The nerve fibers enter the medulla along the arteriolae rectae spuriae. Therefore, there exists a close nervous connection between the juxtamedulla and the medulla. In the pelvic wall, the spiral arteries are accompanied with the nerve fibers which come from the plexus around the interlobar arteries.

The myelinated nerve fibers in the kidney: Several myelinated nerve fibers are recognized along the interlobar and arcuate arteries by means of Weigert-Pal stain. Their physiological significance remains to be resolved.

The renal neurility observed on the basis of neurohumoral transmission theory—

As mentioned above, the blood vessels in the kidney are observed to be
supplied with an abundance of the nerve fibers. An attempt was made to elucidate the nature of these nerves by histochemical methods.

*Catecholamine (CA) and monoamine oxidase (MAO) activity in the kidney:* The distribution of CA was observed by means of Eränkö's fluorescence method. CA fluorescence is present in the media of the arteries and arterioles, the Bowman's capsules and the tubules. There is no fluorescence in the glomerular capillaries. The denervation of the kidney results in a remarkable decrease in the CA fluorescence only in the media of the arteries and arterioles. The distribution of MAO activity in the kidney is almost in accordance with that of the CA fluorescence, and the denervation also causes a reduction in the MAO activity in the media of the arteries and arterioles. The renal arterial system is thus thought to be closely related to the adrenergic nerves. It is presumed that the adrenergic nerves play an important role in maintaining the vascular tension of the arterial system in the kidney.

*Cholinesterase (ChE) positive nerves:* ChE positive nerves were demonstrated by means of Koelle's thiocholine method. The nerves, stained strongly for specific ChE activity and weakly for nonspecific ChE activity, are distributed along the vascular walls. Any nerve fibers cannot be recognized in the glomeruli. After the denervation, the total ChE activity of the nerves disappear, but nonspecific ChE activity of the Bowman's capsules and the tubules remain unchanged. These experiments indicate that there are many ChE positive nerve fibers along the vessels in the kidney.

But, the nerves positive in ChE activity are not always cholinergic, for the possibilities cannot be ruled out that the adrenergic nerve fibers might possess ChE activity, as suggested by Burn's recent observation, too, or that the myelinated nerve fibers are stained for ChE activity. Therefore, it cannot be yet determined whether the vessels in the kidney are supplied with both adrenergic and cholinergic, or only with adrenergic nerves.