Anatomic localization of sympathetic nerves in the hand

The microscopic anatomical localization of the sympathetic nerves within the peripheral nerves and their relationship to the end arteries in the hand has not been fully evaluated. A preliminary study is presented that outlines a method of microscopic identification of sympathetic nerves in the hand. Fresh human tissue consisting of median and ulnar nerves and their arterial supply were used in the study. Sections of these were taken at multiple levels in the forearm, wrist, and hand after the tissue was frozen. The sections were then immersed in a glyoxylic acid solution in order to excite catecholamine fluorescence. Dark-field fluorescence microscopy was then used to view the sections. Light microscopy was also used to examine adjacent sections from the same specimens. The sympathetics are more plentiful in the median nerve as compared to the ulnar nerve at the wrist. They are mostly located, in clusters, in the peripheral aspect of the nerve. Control material consisting of motor nerve, sympathetic chain, and adrenal gland was used to standardize the fluorescence. Histo Fluorescence was then used as a method to define the anatomy of the sympathetic nerves in the hand. (J HAND SURG 8:283-8, 1983.)

Raymond F. Morgan, M.D., Neal R. Reisman, M.D., and E. F. Shaw Wilgis, M.D., Baltimore, Md., and Houston, Tex.

The peripheral sympathetic nerves have been implicated in many pathological states in the upper extremity. The mode of distribution of the sympathetic fibers in the periphery has not been defined. Sunderland\(^1\) noted in 1978 that there are no features of postganglionic sympathetic fibers in man that are sufficiently specific to permit them to be accurately identified histologically. Woolland and Phillips\(^2\) at-
Fig. 1. Adrenal gland. The medulla (M) shows intense fluorescence while the cortex (C) exhibits no fluorescence.

tempted to verify the distribution of sympathetic fibers in the upper extremity of man in 1932. They injected local anesthetic to block nerves and temporarily blocked the sympathetic fibers running with the injected nerve. They observed that the "flush that would follow the release of the blood vessels from their constrictor tone could be observed in the rise of temperature measured by the means of a thermopile." Their observations confirmed the fact that sympathetic fibers pass through the periphery with the ordinary cerebrospinal nerves. They also noted that the line of demarcation between the sympathetic nerve fibers is sharply defined, as are the limits of the cutaneous nerves with which they travel.

As Flatt and Wilgis have noted, the major distribution of the sympathetic supply within the upper extremity is known; however, microscopic identification of its peripheral distribution are lacking.

Branches of the autonomic nervous system innervate almost all blood vessels. The density and function, however, of this innervation varies greatly within different organs and types of vessels. Norepinephrine is stored in the nerve endings and released by the arrival of a nerve impulse. All known vasoconstrictor nerves belong to the sympathetic division of the autonomic nervous system. It has been shown by Dahlstrom in 1965 and by Taxi and Sotelo in 1973 in the sciatic nerve of the rat that the transmitter granules containing norepinephrine are continuously manufactured in the cell bodies of the adrenergic neurons and transported down in the postganglionic axons to the terminals. Most of these postganglionic axons are unmyelinated and belong to the C group of nerve fibers.

Sympathetic fibers innervate virtually all parts of the circulatory system. The density of these sympathetic fibers, however, varies greatly. A relatively large number of sympathetic constrictor fibers innervate small arteries and arterioles in the skin and the splanchnic bed. Fewer adrenergic nerves supply the veins that accompany these arteries. Cerebral vessels have a very sparse innervation.

A great stimulus to the study of blood vessel adrenal...
Fig. 2. Median nerve at the wrist. The peripheral epineurium (E), which surrounds the fascicles (F), has isolated areas of fluorescence. A sympathetic branch (B) can be seen leaving the epineurium.

Adrenergic innervation occurred in 1962 when the Falck-Hillarp technique was presented. Fluorescence of catecholamine-containing nervous tissue was made possible by exposure to formaldehyde vapor. For the first time, a highly sensitive histochemical method was available for demonstration of catecholamines. Darkfield fluorescence microscopy made possible the accurate delineation of sympathetic fibers containing catecholamines. Watson and Barchas in 1977 presented another method of obtaining catecholamine histofluorescence. Cryostat sectioning and glyoxylic acid instead of formaldehyde was used. They used this in the central nervous system to study unperfused rat brains. This newer technique is both faster and more sensitive.

Many studies have been performed in animals to outline the relationship of the sympathetic nerves and blood vessels. It has been shown that vessels that contain smooth muscles in their walls are supplied with nonmyelinated sympathetic nerves. It has also been shown in animals that the walls of arteries are more richly innervated than those of veins. Fluorescent preparations have demonstrated that thick plexuses of adrenergic fibers surround arteries while more open mesh works of fibers surround veins. In general, the sympathetic fibers are contained within the adventitia of arteries; the nerves do not penetrate the media of arteries.

The relationship between the sympathetic nerves and the arteries in the human hand has not been delineated. With the use of histofluorescence, the microscopic localization of sympathetic fibers within the peripheral nerves and arteries in the human could be delineated.

Materials and methods

Specimens were obtained from 10 cadavers. The specimens were harvested within 24 hours after death. Median and ulnar nerves as well as digital arteries were obtained from the midforearm to the proximal interphalangeal joint. The specimens were immediately frozen at -20°C. A modification of the Watson-Barchas technique was used. The specimens were sectioned in a cryostat. The slides were then placed in a 2% glyoxylic
acid solution for 5 minutes. The slides were removed and dried in an air stream. After drying, the sections were transferred into a gassing chamber that consisted of a Coplin jar at 100° C. The slides remained in contact with the gas for 5 minutes. The slides were immediately viewed through a Zeiss dark-field fluorescence microscope. The specimens were photographed with Ektachrome film rated at 800 ASA. Additional sections were obtained from the same specimens and treated with Mallory trichrome staining technique. These were photographed by routine light microscopy.

**Results**

Appropriate control specimens were obtained and stained by the outlined fluorescence technique. Median motor nerves revealed no fluorescence. Sympathetic chains specimens, however, revealed consistent intense fluorescence. Sections of adrenal glands from the patients revealed intense fluorescence of the medullary portion of the gland and no fluorescence of the cortical portion (Fig. 1).

Sections taken of the median nerve 10 cm proximal to the proximal edge of the carpal tunnel were similar to those obtained in the carpal tunnel. Similarly, sections of the ulnar nerve taken 10 cm proximal were similar to sections of the same nerve obtained at the wrist. These sections revealed small localized intense areas of fluorescence only in the external perimeter of the epineurium (Fig. 2). The median nerve contained six to eight of these fluorescent areas around its perimeter, while the ulnar nerve contained three or four groups around its perimeter. Additional sections were obtained 1 cm distal to the bifurcation of the common digital arteries in both the median and ulnar distributions. The digital arteries were also obtained within the specimens. The digital nerves had several areas of intense fluorescence only around the perimeter of the nerve within the epineurium. On rare occasions, branching could be seen associated with the fluorescent areas. The digital arteries had consistent intense fluorescence only within their adventitia. No fluorescence could be demonstrated within the media (Fig. 3). The digital nerves
within the median distribution revealed more intense fluorescence and a greater number of sympathetic rich fluorescent areas than did the ulnar digital nerves of the same cadaver specimen. Intense fluorescence could be seen both within the peripheral epineurium and the adventitia of the proximal digital nerves and arteries (Fig. 4).

Conclusion

The fluorescence associated with the median nerve was quantitatively greater than that of the ulnar nerve in specimens taken from the same cadaver. The fluorescent bundles of sympathetic nerve fibers coalesce only within the peripheral edge of the epineurium. No fluorescence could be consistently demonstrated within the central portion of the median nerve, ulnar nerve, or digital nerves. Only the adventitia of the digital arteries exhibited fluorescence. No fluorescence could be demonstrated within the media of the vessels. Because of the limited magnification possible with the dark-field fluorescence microscope, individual sympathetic axons could not be viewed. These individual sympathetic axons, which belong to the C group of nerve fibers, measure approximately 1 μ. Therefore, only large groups of sympathetic axons could be viewed with routine dark-field microscopy.

These findings appear to confirm the fact that sympathetic axons travel with peripheral nerves and send frequent branches to arteries throughout their course. The sympathetic axons are then apparently distributed only within the adventitia of the arteries (Fig. 5). The median nerve distribution has, as well, apparently greater sympathetic innervation than does the ulnar distribution.

A modification of a well-established method of studying the sympathetic nervous pathways in the central nervous system of animals has been successfully adapted for examination of the peripheral sympathetic nerves in man.
Fig. 5. Median nerve at the wrist and digital artery and nerve showing peripheral epineurial and adventitial location of sympathetic fibers.

REFERENCES