samples was just within the limit of detection. Part of the low ChAc activity in non-junction and myo-tendinous samples may be due to intramuscular nerve branches.

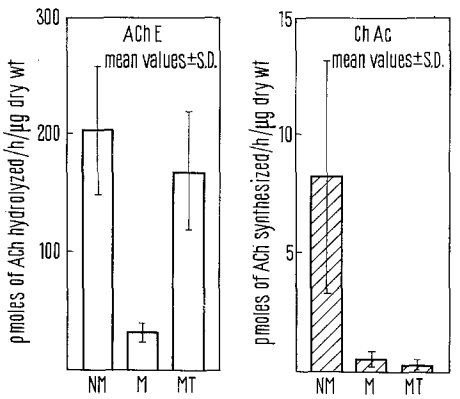


Fig. 2. Activities of AChE and ChAc in the dissected samples NM, M and MT (symbols as in Figure 1). From 3 animals 15 samples of the various kinds were assayed for each enzyme.

The above results establish that there is a close correspondence between the ChAc and AChE activities in neuro-muscular junctions, whereas in the myo-tendinous junctions a high AChE activity is contrasted to the almost total lack of ChAc. From these observations we conclude that ACh is not synthesized near the myo-tendinous junctions and that the AChE present there does not normally hydrolyse ACh.

*Zusammenfassung.* Topographischer Nachweis hoher Acetylcholinesterase-Aktivität an der Übergangsstelle Muskel/Sehne und, im Unterschied zur neuromuskulären Verbindung, an dieser Stelle kaum messbare Aktivität der Cholinacetyltransferase, was ohne Beziehung zur cholinergen Erregungsübertragung steht.

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## Evidence for a Spinal Sympathetic Regulation of Cardiovascular Functions[1]

The reflex control of cardiovascular functions is commonly thought to be exclusively integrated at supraspinal levels. Spinal sympathetic reflexes, though known to exist[2], are not considered to be activated by haemodynamic events. Sympathetic rami, however, represent a simple pathway through which afferent information from heart and blood vessels may reach the cord and reflex signals may be returned to the cardiovascular system without involvement of the brain stem. Reflexes of this type might subserve local segmental regulation of cardiovascular functions much more aptly than the classical medullary reflexes involved in the overall control of systemic circulation.

These reflexes could be conveniently studied by recording the electrical activity of the sympathetic rami. Indeed, we have recently shown[3] that transient coronary occlusion in cats can modify the activity of a sympathetic preganglionic outflow to the heart (i.e. the third left thoracic ramus communicans, T3, which is known to contribute significantly to the efferent innervation of the heart[4] and particularly to myocardial contractility[5]). These effects were reflex in nature and consisted most often in increases in sympathetic discharges. They were found to be independent of vagal fibres and present in intact, decerebrate and spinal preparations. This was the first demonstration of a cardio-cardiac spinal sympathetic reflex. In order to investigate whether cardiac sympathetic spinal reflexes can also be elicited by a more normal haemodynamic event, and therefore participate in the physiological rather than pathological regulation of circulation, we have studied the effects on the same sympathetic outflow of changes in arterial blood pressure. As will be described, increases in arterial blood pressure can reflexly modify the activity of T3 fibres in spinal vagotomized preparations.

Experiments were performed on 24 cats, anaesthetized by i.p. injection of pentobarbital sodium (35 mg/kg). Preparations were paralyzed with gallamine triethiodide and artificially ventilated. In all cats the spinal cord was sectioned at C1 and both vagi cut. The left stellate ganglion was exposed retro-pleurally and T3 was dissected under a microscope into tiny filaments until a single or a few active fibres could be isolated. Electrical activity of the sympathetic fibres was suitably amplified and recorded on film from CRO screen, simultaneously with carotid arterial pressure. Other recording details have been described[3]. The rises in arterial pressure, obtained either by stenosing or occluding the thoracic aorta at various sites (by pulling a ligature placed around it) or by i.v. injection of pressor drugs (noradrenaline and angiotensin) were usually tested several times for each fibre and for each multifibre preparation.

We studied the activity of 54 single preganglionic sympathetic fibres and 34 multifibre preparations (Table). This Table shows that single fibres could respond to rises in arterial pressure either by decreasing or increasing their firing rate, with some predominance for the first type of response. A reduction in firing rate was obtained far more frequently from multifibre preparations. For each single fibre and multifibre preparation the type of response was consistent through several and different trials.

The Figure shows an example of reduction in firing rate of a single fibre following occlusion of the thoracic aorta. This type of response was found to be graded according to the amplitude of the blood pressure rise, however obtained (by constricting the aorta or by injecting pressor drugs). Since this response might have

[1] Aided in part by the USPHS Grant No. 5166025. We wish to express our gratitude to Dr. A. Zanchetti for his advice and reading the manuscript.

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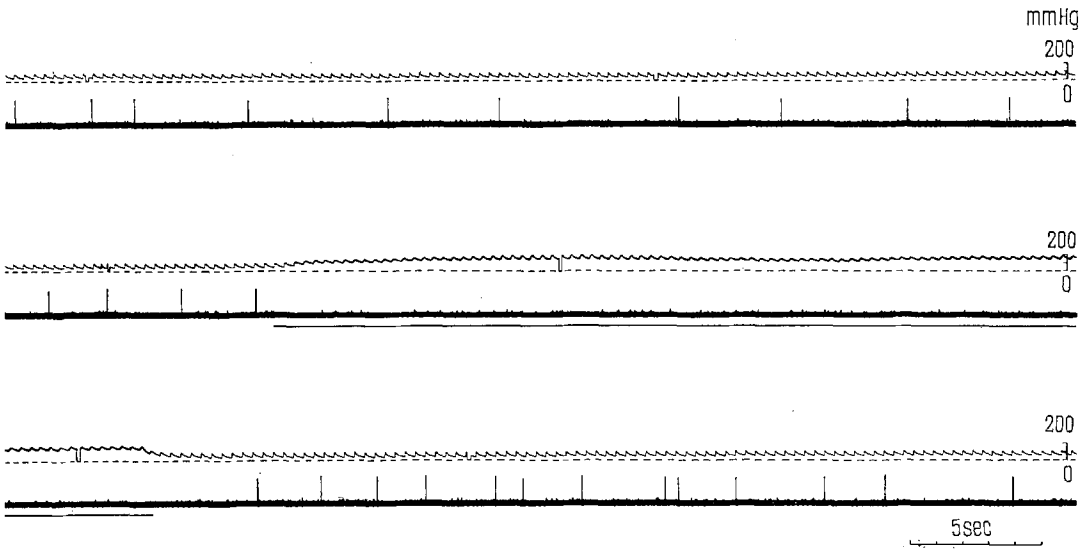
Effects of blood pressure rises induced by aortic stenosis and/or occlusion (A), angiotensin (Ang) or noradrenaline (NA) injection on the activity of single fibres and multifibre preparations in T3

| | No. of single fibres or multifibre preparations | Decrease in firing rate | Increase in firing rate | Unmodified firing rate |
|---|---|---|---|---|
| Single fibres | 54 | 18<br>5: A, Ang, NA<br>2: A, Ang<br>10: A<br>1: Ang | 12<br>2: A, Ang, NA<br>1: A, NA<br>9: A | 24<br>3: A, Ang, NA<br>4: A, Ang<br>2: A, NA<br>15: A |
| Multifibre preparations | 34 | 16<br>3: A, Ang<br>1: A, NA<br>10: A<br>1: Ang<br>1: NA | 5<br>1: A, Ang, NA<br>1: A, Ang<br>1: A, NA<br>2: A | 13<br>2: A, Ang, NA<br>2: A, Ang<br>2: A, NA<br>7: A |




Single preganglionic sympathetic fibre (lower trace), spontaneously active, abolishing its firing during an increase in arterial blood pressure (upper trace) obtained by aortic occlusion (marked by a bar). Continuous recording.

been attributed to a direct effect of blood pressure and of oxygen supply on spinal sympathetic neurones[6], its reflex nature had to be demonstrated. This was accomplished in 5 experiments, by observing the disappearance of the response after interrupting the afferent limb of the reflex (namely by sectioning the sympathetic chains from the stellate ganglia to T4).

An increase in sympathetic discharge was also frequently observed (Table). Fibres which augmented their firing rate could be either spontaneously active (the increase in firing rate being sometimes as large as 5–10 times the resting values) or spontaneously silent and firing only during rises in blood pressure. This second type of response could also be graded during various rises of blood pressure, however obtained, and again the most important factor in evoking the effect appeared to be the amplitude of the blood pressure rise. This response too could be abolished, after section of sympathetic chains from stellate ganglia to T4.

We conclude that in spinal vagotomized cats the activity of sympathetic fibres isolated from a preganglionic outflow mainly distributed to the heart can be reflexly modified by increases in arterial blood pressure. Such spinal sympathetic reflexes elicited by haemodynamic events suggest the contribution of spinal mechanisms to the regulation of cardiovascular functions. However at present it is still unknown whether the two different types of response, inhibitory and excitatory, are due to different cardiovascular receptors or to different populations of sympathetic neurones.

*Résumé.* La décharge de fibres sympathiques préganglionnaires isolées, faisant probablement partie de l'innervation efférente du cœur, a été étudiée sur des chats spinalisés et vagotomisés par rapport à des augmentations de la tension artérielle provoquées mécaniquement ou pharmacologiquement. Les réponses obtenues consistaient soit en une diminution soit en une augmentation de la décharge sympathique, le genre de réponse étant constant pour chaque fibre, et de nature réflexe.

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