On the Paraganglia in the Ganglion of the Vagus Nerve.

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Recently the Japanese Surgical Society has undertaken a big problem which is the resection of the carotid paraganglion as a surgical treatment for bronchial asthma. This carotid paraganglion belongs, as do as the cardiac paraganglia discovered by Penitschka\(^1\) and Seto\(^2\) in 1931–35, to a sort of gland of internal secretion which from various points of view stands in opposition to the medullary substance of the suprarenal gland.

A comparison of these two groups of ductless glands set up in opposition each other reveals that though they belong to the nervous accessory organs (Kohn,\(^3\) Kose,\(^4\) Watzka\(^5\)) standing in intimate relationship with blood vessels and nerves, there are between them following the differences.

1. Embryologically: The carotid and cardiac paraganglia appear relatively late in foetal time, but they remain throughout life. On the contrary, the medullary substance of the suprarenal gland and other paraganglia of the same kind (aortic paraganglia of Zuckerkandl\(^6\) etc.) appear early in foetal time, but soon after birth gradually recede and disappear leaving only slight microscopical evidence, one exception being the medullary substance of the suprarenal gland, which remains throughout life.

2. Innervation: The innervation of the carotid and cardiac paraganglia are supplied mostly through the parasympathetic nerves, especially by the vagus, while the medullary substance of the suprarenal gland is innervated through the sympathetics.

3. Cytologically and physiologically: The parenchyma of the sympathetic paraganglia consists of chromaffine cells. The extract of this parenchyma contains adrenalin which causes the rise of blood pressure. The parasympathetic paraganglia on the contrary have far fewer chromaffine cells, or at times these are even absent (Kose,\(^4\) Watzka\(^5\) etc.). And according to many investigators the extract of these causes a fall in blood pressure.
As pointed out above (embryologically, physiologically etc.) the carotid gland and the cardiac paraganglia both belong to the ductless glands standing in opposition to the medullary substance of the suprarenal gland. Then on the basis of above shown similarity, if the resection of the carotid paraganglion is effective in the treatment of bronchial asthma, the resection of both the carotid and cardiac paraganglia should be consequently much more effective. In addition, since the functions of these paraganglia belonging to the parasympathetics rely upon the aortic, carotid sinus and cardiac reflexes of Hering, it follows that by the resection of the sensory nerves involved with this reflex fall of blood pressure, such as the aortic nerve (formerly termed N. depressor and partly distributed in the auricle) and the sinus nerve the bronchial asthma should be similarly relieved. If this is true it likewise follows that simultaneous resection of both parasympathetic paraganglia and sensory nerves, each dependent upon the other, should be much more effective than resection of either one of them.

Seto, one of our investigators, expressed the opinion in his report (1935) on the cardiac paraganglia, that the parasympathetic paraganglia would not only be situated at the two places described above, but distributed in other places along the course of the vagus nerve also. Muratori in 1932 discovered such a paraganglion, in- and outside of the ganglion nodosum of the vagus nerve in birds. But now we can not overlook the work of White, who has found out recently by chance in his histological study of the carotid gland that there is a special new organ with great similarity to the carotid gland accompanied by the ganglion nodosum of the vagus nerve in the human. However, he had to refrain from publishing his decisive diagnosis as a paraganglion, because he did not study on its innervation with the silver impregnation method.

Recently we have studied the root part of the vagus nerve in the adult man by longitudinal frozen sections stained by Seto's modification of Bielschowsky's silver method. We were able to find very small groups of cells (paraganglia) having the structure like the carotid or cardiac paraganglia. They are generally of small size, scattered in the ganglion nodosum of the vagus, chiefly in the connective tissue between the bundles of nerve fibres. In comparison of size these are only about one fourth of the size of the cardiac paraganglia and about one half of the size of the carotid paraganglion.

In the microscopical examination of these paraganglia of the ganglion nodosum, as shown in the Fig. 1, the parenchymal cells are all clear, containing a round or oval nucleus, and grouped to form the lobules, which are invested by the interlobular connective tissue. The parenchyma is rich in blood vessels, especially in fine veins and capillaries, and is characterised by the peculiar distribution of nerve fibres. The extracapsular
nerves supplying these paraganglia consist of mostly relatively thick fibres belonging to the vagus nerve (parasympathetic) and partly very fine fibres (sympathetic type). These fibres penetrate the capsule and enter the parenchyma of the lobules. Under low power magnification the terminal fibres of the parasympathetic nerves (vagus) can be seen distributed throughout the parenchyma. These fibres vary considerably in thickness and appear to terminate in a dendritic pattern (Fig. 1). However under high

![Fig. 1. Nonchromaffine paraganglion inside of the ganglion nodosum of the vagus nerve in the human. v. nerve bundle of vagus; b small artery; v small vein; p nerve plexus in the capsule; i interlobular nerve plexus; small veins and special nerve fibres found out so richly in the gland parenchyma. The Seto's silver method, 350 times magnified, 1/3 diminished.](image)

power magnification one can see that these end branches further divide and ramify forming a very complicated network of fine anastomoses which lie in close approximation to the parenchymal cells (Fig. 2). This ter-

![Fig. 2. The same paraganglion, showing the manner of nerve ending in an aggregation of gland cells. k nucleus of gland cells; p nerve plexus around the cells aggregation; n terminal network of special nerve fibres in the cells aggregation, which indicate the great variety of thickness. The same staining, 900 times magnified, 1/2 diminished.](image)
Terminal reticulum is very similar to that found in the medullary substance of the suprarenal gland (Stöhr)\textsuperscript{10}. However comparison of this terminal reticulum of the parasympathetics (vagus) in these paraganglia with those of the vegetative (autonomic) nerves found in the walls of blood vessels and in smooth muscle tissue etc. reveals a marked difference in the fine structure. The very delicate and complicated terminal-network described in the cardiac paraganglia by Seto in earlier investigations (1933) has since been shown to be in error. This was due to too strong silver stain. Today by use of improved impregnation we have shown the fibres of both the cardiac and carotid paraganglia to be similar—both belonging to the parasympathetics.

As described above the nonchromaffine paraganglia standing in opposition to the medullary substance of the suprarenal gland—parasympathetic paraganglia, especially of vagus—are represented not only by the cardiac and carotid paraganglia, but also by the paraganglia of the vagus ganglion. And the existance of other such groups elsewhere may be supposed.

In conclusion with reference to the surgical treatment of bronchial asthma the resection of the carotid paraganglion can be done very easily. The simultaneous resection of the cardiac paraganglia and the paraganglia in the vagus ganglion with the above postulated effect would then offer a perfect cure for bronchial asthma. Unfortunately in practice it is impossible to resect these paraganglia (cardiac and vagus) because of their inaccessibility surgically. However from the above description this end may be partially realized by resecting the aortic and sinus nerves at the time of carotid paraganglion resection—a relatively simple procedure. The resultant beneficial effect in the treatment of bronchial asthma is here only postulated, clinical trials in the future will verify or disprove this theses.

**Bibliography.**

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