THE CAROTID BODY AND ITS TUMOR
1. An Anatomical and Physiological Update

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SUMMARY :

Contemporary and classical knowledge on the carotid body is reviewed. A summary of the present data on the anatomy, histology, and physiology of the carotid body is made. The prospective role of the carotid body in neural transplantation is noted.

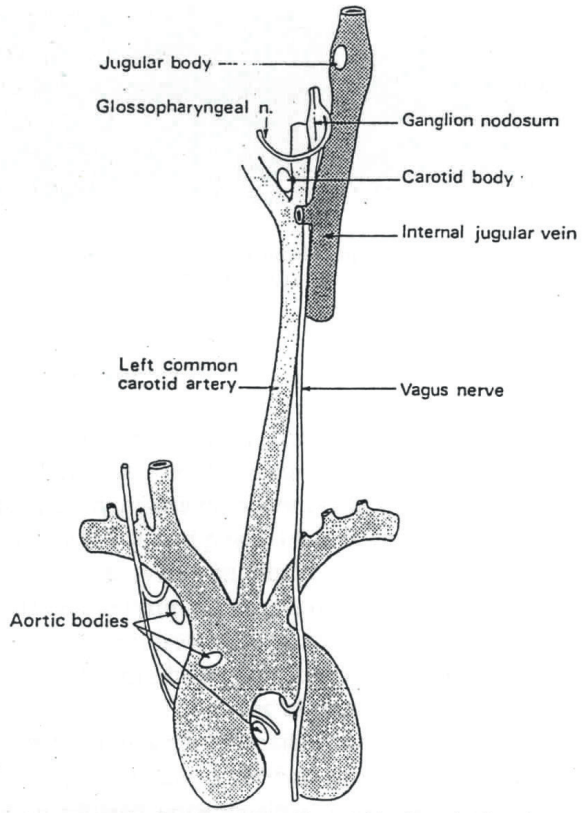
KEY WORDS :

Carotid body.

INTRODUCTION

The carotid body, a tiny anatomical structure located at a peculiar locus, the carotid artery bifurcation, has attracted interest both anatomically and physiologically.

Before starting the review, a strict differentiation with similar organs, carotid sinus, aortic bodies, and jugular body which are very commonly confused with the carotid body, must be made (Fig. 1). Carotid sinus, a slight dilatation in the wall of the terminal portion of the common carotid artery and of the internal carotid artery at its origin, responds to alterations in blood pressure (pressoreceptor) (9, 10). Aortic bodies, and the carotid body itself, respond to changes in the chemical composition of the arterial blood (chemoreceptors) (9, 10) The jugular body lies in the adventitia of the superior bulb of the internal jugular vein. It has a chemoreceptor function like the carotid and aortic bodies (10).



1. Diagrammatic demonstration of carotid body and other chemoreceptor organs.

HISTORICAL BACKGROUND

Description of the carotid body was first made by Haller in 1743 (9, 15). For years it was regarded as an endocrine gland, chromaffin body, paraganglion, or a cavernous vascular organ (9, 17). In 1928 de Castro (1, 9) suggested that on the basis of its peculiar histological appearance the carotid body might represent a special sense organ capable of perceiving changes in the chemical composition of the arterial blood, and this was conclusively demonstrated by Heymans in 1930 (1, 9).

EMBRYOLOGY

It is generally accepted that the carotid body first appears as a condensation of mesodermal cells in the wall of the third arch artery and contains mesoblastic and neural components (17). Contribution by the pharyngeal endoderm is not accepted (8). The neural components have been thought to arise from the neural crest (15), the ganglion nodosum of vagus (5), and the petrous ganglion of the glossopharyngeal nerve.

GROSS ANATOMY

The carotid body lies deep in the bifurcation of the common carotid artery between the two branches.

It is a small, flattened, oval structure, 2-5 mm in diameter, with a characteristic structure composed of epitheloid cells, which are in close relation to capillary sinusoids, and an abundance of nerve fibers. Surrounding the carotid body is a delicate fibrous capsule. The nerves to the carotid body are filaments from the pharyngeal and possibly from the superior laryngeal branches, which join with similar filaments from the glossopharyngeal nerve and the superior cervical sympathetic ganglion to form the intercarotid plexus between the internal and external carotid arteries at the bifurcation. The vagus fibers are visceral afferents that terminate in the carotid body. The chemoreceptor afferents from the carotid body reach the vagus nerve through branches of the pharyngeal or superior laryngeal nerves (10).

In an extensive study performed on 32 routine autopsies, and one fresh surgical biopsy specimen morphological findings were as follows: The carotid bodies were clearly demarcated in both the young and the elderly. The largest amount of tissue was seen in fixed sections from a woman of 75 years who had died from miliary tuberculosis. The carotid bodies were 8.7x4.3 mm in their greatest dimensions. In children they were smaller (17).

HISTOLOGY

The carotid bodies form a localized mass of lobules within the intercarotid connective tissue and adventitia of the carotid arteries. A small nutrient artery can be identified arising near the bifurcation supplying the lower pole. Adjacent connective tissue is rich in arteries, veins, and medullated and nonmedullated nerve fibers (17).

Miniglomerula have been found in the carotid bifurcation region at the same distance from the carotid body itself and even around the common carotid artery of the cat. Both physiological and ultrastructural features of miniglomerula were found to be identical to those of the carotid body (1).

The carotid body is composed of irregular groups of epitheloid cells in intimate relation to capillary sinusoids cells in intimate endothelium. Two types of parenchymal cells can be distinguished with the light microscope on the basis of differing nuclear characeristics. The most obvious, the Type I (glomus cell), contains many small, dense cored vesicles resembling secretory granules. These granules have been shown to contain catecholamines and 5-hydroxytriptamine. These cells occur in small clusters that are surrounded by Type II cells which are devoid of cytoplasmic granules. Many nerves ramify throughout the organ and end on the Type I cells. It has been traditional to accept that that glomus or Type I cells are the chemoreceptors and that they pass information on to associated afferent nerve endings. The Type II cells are believed to be supportive elements (7).

PHYSIOLOGY

Carotid bodies, which are chemoreceptors located outside the central nervous system, transmit signals to the respiratory center in the medulla oblongata to help regulate respiratory activity.

Changes in arterial oxygen concentration have no direct effect on the respiratory center itself, but when the oxygen concentration in the arterial blood falls below normal, the chemoreceptors, namely carotid and aortic bodies become strongly stimulated.

The rate of nerve impulse transmission from a carotid body is particulary sensitive to changes in arterial PO_2 in the range between 60 and 30 mm Hg, which is the range in which the arterial hemoglobin saturation with oxygen decreases rapidly.

The basic mechanism of stimulation of the carotid body by oxygen deficiency is that the blood flow through the carotid body is extremely high, the highest that has been found for any tissue in the body. Because of this, the arterio-venous oxygen difference is less than one volume per cent, which means that the venous blood leaving the carotid bodies still has a PO_2 nearly equal to that of the arterial blood. Therefore, it is the arterial PO_2 that normally determines the degree of stimulation of the chemoreceptors. The exact means by which low PO_2 excites the nerve endings in the carotid bodies is still unknown. However, recent studies suggest that the nerve endings themselves are directly sensitive to the lov PO_2.

The direct effects of CO_2 and H+ ion concentrations on respiratory center itself are so much more powerful than their effects mediated through the carotid and aortic bodies that for practical purposes the indirect effects through the chemoreceptors may be disregarded (11).

EXPERIMENTAL PHYSIOLOGY

Recent experimental work on various aspects of carotid body chemoreceptor function has led to better understanding of this organ's physiology. A brief summary of the experimental work published in the last two years will be given in the following paragraph.

Time-dependent effect of hypoxia on carotid body chemosensory function has been studied in anesthetized cats by Barnad et al (4) and it was concluded that chronic hypoxia will sensitize the O_2 responsive mechanism, thereby augmenting the chemosensory function. Flow-dependent chemosensory activity in the the carotid body has been studied in vitro by Alcayaga et, al. (2) and it has been found that chemosensory discharge frequency recorded from carotid bodies superfused in vitro is determined by the superfusion flow when all natural chemoreceptor stimuli are held constant. In another in vivo research study by Vizek et al. (19) it is shown that inter individual variation in hypoxic ventilatory response is associated with comparable variation in hypoxic sensitivity of carotid bodies, thus differences in peripheral chemoreceptor sensitivity may contribute to inter individual variability in hypoxic ventilatory response. Lopez-Barneo et. al. (16) have studied chemotransduction mechanisms in the carotid body and concluded that ionic conductances and particularly the O_2-sensitive potassium current play a key role in the transduction mechanism of arterial chemoreceptors. In two studies by Habeck et. al. (12, 13) it has been shown that the development of carotid body enlargement is not only dependent on an elevated blood pressure but in hypertensive rats the carotid body volume is likely to be dependert on the rat strain studied and independent of the blood pressure level. Barer at, al. (3) have found evidence of hyperventilation without carotid body enlargement in hypertensive rats. In another study by Huckstorf et al. (14) it was concluded that long-term stimulation of the peripheral arterial chemoreceptors influences the adjustment of the plasma volume and the carotid body volume is also higher only in chronic hypoxic spontaneously hypertensive rats.

CAROTID BODY AND PROSPECTS IN NEURAL TRANSPLANTATION

In a recent review of nerve-cell grafting in Parkinson's disease (18) carotid body is listed among the potential sources of donor cells that may be an alternative to the use of human fetal nerve cells.

In an almost isochronically published research work by Bing et al. (6) comparative effects of adrenal medullary cells, carotid body glomus cells, and PC12 cells from a rat pheochromocytoma cell line transplanted into the striatum of adult rats with unilateral 6-hydroxydropamine nigrostriatal lesions have been studied. No significant differences in rotational behaviour were seen in the PC12 cell recipient groups. Grafted cells could be identified in all the adrenal medullary and carotid body glomus cell recipients. One month after transplantation. However, the number of surviving cells was quite limited. Tyrosine hydroxylase (the rate limiting enzyme for catecholamine synthesis) -positive fibers were present adjacent to the transplants in these latter graft recipients, but the fibers appeared to be of host origin rather than from the grafts. The behavioural data showed that the implantation of both adrenal medullary and carotid body glomus cells significantly reduced the amphetamine-induced rotational behaviour in the lesioned rats compared to the control group. The authors conclude that the present study raises questions about whether the behavioural recovery is due to catecholamine released by the grafted cells or from graft-induced recovery of host systems.

The result obtained from this, to our knowledge, first and only research work on the viability of carotid body cells in neural grafting, is encouraging. It opens the way for further detailed experimental studies. Taking into account factors such as nerve growth factor, recent advances in cell culture techniques, and genetic engineering in immortal cell lines which leads to production of cells secreting one specific biochemical product, carotid body and probably chemodectoma cells seem to be a serious alternative to fetal cell grafting. Surgical accessibility of the carotid body is another advantage over the adrenal medulla.

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